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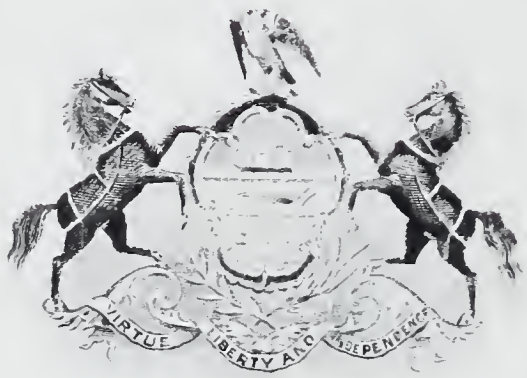

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Popular Science Lectures

SEASON OF 1924-1925

Presented by Members of the Faculty of

The Philadelphia College of Pharmacy and Science

and published under the auspices of the

American Journal of Pharmacy

SINCE 1825 A RECORD OF THE PROGRESS OF PHARMACY AND THE ALLIED SCIENCES

Volume No. III

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FOREWORD.

The third volume of "Popular Science Talks," is issued in compliance with requests which have come from many quarters, and in view of the pleasing reception given to the first and second volumes.

Especially have these requests come from public libraries and from high schools, where, in some instances, the books have been used in the chemistry and science reading courses.

The lectures which constitute the volume represent the effort of the Philadelphia College of Pharmacy and Science to contribute to the educational welfare of the community at large by means of popular scientific discussions.

These talks were delivered to large audiences by members of the Faculty of the institution and were abundantly illustrated by experiments, lantern slides and specimens. They were subsequently broadcast from several Philadelphia radio transmitting stations.

Given in a form which is simple and understandable they are of particular value to those who are interested in scientific subjects in general and they are not without value to persons who are technically trained along particular lines.

It is the intention of the College to continue this publication and an outline of the series of lectures for the coming season is printed at the end of the volume.

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ARCTIC AND TROPICAL PENNSYLVANIA

By Henry Leffmann, A. M., M. D.

Lecturer on Research, Philadelphia College of Pharmacy and Science

THE WRITTEN history of Pennsylvania, like that of the whole of North America, dates back only a few hundred years, beginning with the arrival of the first Europeans on our shores. We have, unfortunately, only vague records of the savage tribes that were in possession at the time of the discovery of the Continent. Prior to these savages, it seems likely that other savage races occupied the land, and some authorities think that the American Indians (now often designated in American anthropologic literature as "Amerinds") are of Mongolian origin.

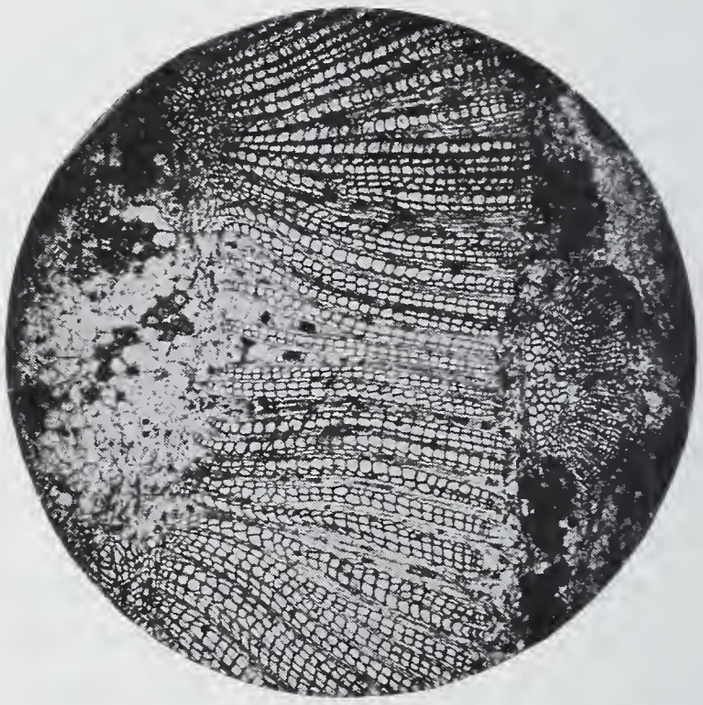
Whatever may have been the history of the human beings who first occupied the territory now included in Pennsylvania, we have in the testimony of the rocks a history of many thousands of years, during which the climate and the physiographic nature of the land underwent many changes, and while a vast amount of these changes has left no great impression, a few have, and it is to two characteristic conditions that attention is to be drawn.

The study of the history of the earth as evidenced in the rocks is known as "Geology." It is a science that has been pursued with vigor for less than two hundred years. For many centuries the teachers and investigators in the civilized world were satisfied that the account of creation given in the book of Genesis was the whole story. There were, of course, a few doubters for there has been no period in the history of the world when all men and women were of one opinion. Among the manifestations of difference in the earlier history of the earth was the fact that in many places the remains of animals and plants were found, such as shells, bones, and impressions of organized forms. These were generally regarded as the remains of animals and plants killed in the Flood.

About the time when our colonial forefathers were beginning to manifest actively their dissatisfaction with the actions of the

Mother Country, certain men in Europe were beginning scientific inquiry into the rocks, their nature and the remains found in them. It became increasingly evident that the story of the development of the earth was a very long one, and the literal accuracy of the Genesis narrative was questioned. Very active discussion arose on this question, but it is not within the scope of this article to give the details. At the present day geologists are left to their own methods and opinions in discussing the problem of the age of the earth and the course of its development.

The tendency at the present day is to allow a very long time for the succession of geologic ages. Scientists do not hesitate to suggest billions of years. Much is guesswork, or at least reason-



Section of coal x 10, showing portion of stem of Lyginodendron oldhamium. Photomicrograph by H. Leffmann.

ing based on premises that are of doubtful value. Almost all, however, who study the subject are impressed with the fact that the lapse of time has been very great, certainly many thousands of years. In the determination of the order of succession of the formation of the different rock masses, the organized remains afford some guide, but even here, the data are unfortunately scanty and may be misleading. It appears, however, that as far as Pennsylvania and adjacent regions of North America are concerned, two well-marked contrasting periods have occurred. They were separated by a very long interval, but no trustworthy dates can be

given. They have left their traces in unmistakable form upon the rocks and soils of region, and have profoundly modified the scenery of the area and also its economic relations.

Tropical Pennsylvania.

The main characteristic of tropical regions is the abundance and luxuriant character of the animal and plant life. This is due to the fundamental climatic condition, warmth and moisture. Such a condition can be easily observed and studied in the tropical regions of the earth today. The tropical period in Pennsylvania is recorded especially in the coal deposits. It was evidently a period of long duration, and the vegetable remains are principally ferns and allied plants. These remains are, however, largely in the forms of impressions of the leaves upon the slaty materials associated with the coal. In many cases in which remains of organism, animal or vegetable are preserved, the structure of organism is recognizable in very minute form, but in other cases merely the external covering or the impression is retained. In the case of the petrified trees in the remarkable petrified forests of Arizona, the minute structure can be easily detected by cutting thin sections of the mass, and examining these under the miscroscope. The tissues of the plant have been substituted by silica, more or less colored by foreign substances, such as iron compounds, so that the specimen resembles agate in hardness and appearance. Grinding is therefore required but this can now be done in very satisfactory manner, and when sections of these Arizona petrified trees are so examined under high power, the so-called "bordered pits," characteristic of pine wood are found, showing that these trees are of that type.

Similarly, in coal itself and in nodules occurring in the coal, remains of vegetable tissues can be clearly recognized. In most of these cases, the structure is that of ferns or their allies, but the specific forms are almost always of plants not now existing on the earth. In the earlier work in this line, sections were made by grinding, but a later method is the soaking of the mass in hydrofluoric acid for some time, by which much silicious matter is removed, and ultimately the specimen becomes so soft that it can be cut in thin films. By this means many interesting data have been obtained. It has been found, for instance, that pollen and spores entered largely into the formation of coal.

The transformation of plant structures into coal is a slow process, accomplished principally by the immersion of the plants in water or so covered from the air as to permit of a peculiar oxidation, by which the hydrogen, with the oxygen, is removed by degrees, so that the mass becomes proportionately richer in carbon. The early stages of such a change are seen in peat; later stages in lignite and brown coal. A further advance is noted in the so-called soft coals which still contain considerable hydrogen and some oxygen. Of course, most of the mineral matter contained in the plant, remains in the coal. This constitutes the ash, and is very different in proportion in different samples.

SECTION OF STEM OF ASTEROMYELON.

Section of coal x 10, showing portion of stem of Asteromyelon. Photomicrograph by H. Leffmann.

If we examine the coal deposits of Pennsylvania we find several markedly different forms. In the eastern part of the state, the strata generally have been much disturbed, in many cases almost set in an upright position. This evidences great pressure and heat, and the coal deposits have undergone distillation by which almost all the constituents capable of volatilizing have been removed, and the residue consists of little else than carbon with the mineral matter originally in the plant tissue. This material constitutes "anthracite," which is such a valuable fuel. The anthracite deposits of Pennsylvania are practically unique. Some approach to them exists in other places, but nothing so directly applicable as

a smokeless fuel. Passing westward it is noted that the rocks become less disturbed and distorted, and coal deposits are found containing notable amounts of hydrogen, constituting the semi-bituminous or steam coals, fuels of excellent quality for some industrial purposes, especially locomotive firing, as the mass takes fire quickly, and burns with comparatively little smoke. Still further west the strata have been scarcely at all disturbed, and the coal beds lie horizontal or nearly so. These deposits have suffered little change, and contain a considerable amount of hydrogen, so that they yield a large volume of gas burning with bright flame, and are known as gas-coals. They are the coals that were used originally in the making of illuminating gas. Gas-making establishments were extensively developed during the first half of the nineteenth century, using this coal, and producing valuable by-products, tar, ammonia-liquor, and coke. A process of making gas by directing steam on hot coke or anthracite was developed, and the cost being much less, the old-fashioned coal-gas went out of favor and the newer product known as water-gas was largely introduced. As first produced this gas burns with an almost non-luminous flame. It is very suitable for heating but not for lighting; to fit it for the latter purposes it must be enriched, which is done by introducing oils.

The exact manner in which coals are formed has been of late, a matter of dispute, but it seems likely that in many cases, the successive vegetations dropped into the boggy soil in which they grew, and being covered by water and mud, underwent the slow and peculiar oxidations that have given rise to the coal. All stages of these changes from peat, which is the beginning, to hard coal, which is the final, can be observed when the deposits of different regions are compared. The coal deposits of Pennsylvania are among the most valuable in the world.

Seemingly abundant as are the remains from the coal and associated rocks, it is unfortunately evident that but a small portion of the life, animal and vegetable, is preserved. The department of science which deals with the fossil and other remains of living organisms is known as paleontology, a word made up from Greek terms and meaning "old being." It has two main branches, paleobotany and paleozoology, but the latter term is little used, those who study animal remains being usually designated as paleontolo-

gists. While modern science recognizes clearly that all living organisms may be included in "biology," naturalists, both those concerning with extinct species and those who study existing forms, mostly specialize either in botany or zoology. More or less over-confidence in the interpretation of remains is exhibited by paleontologists of both types and it would be well if all students of these subjects would read and remember Charles Darwin's chapter on the imperfection of the geological record, in his "Origin of Species."

BOULDER ON CREST OF PENOBSCOT MOUNTAIN, LUZERNE CO., PA.
From Vol. Z, Second Geological Survey Pennsylvania.

The animal life of the coal period may have been rather characteristically reptilian. The great liability of insect forms to total destruction under the ordinary conditions of climate and soil, would lead to a loss of many species. Some insect remains are preserved, and it is worth noting that in the Belgian coal-fields, remains of dragon flies with a wing expansion of about twenty-nine inches have been found. The recently devised methods of sectioning coal samples, mentioned above, have yielded interesting results, and have given rise to a new opinion in regard to the formation of coal beds, namely that in many cases these have not been formed by

the simple accumulation of vegetable remains at the place where the coal is found, but most of the material has drifted or been swept in from other localities. It has been shown that pollen and the spores of cryptogamous plants have contributed to coal formation in larger proportion than was formerly supposed.

If the earth had undergone no violent changes since the coal period, we would, of course, have a much more vivid picture of the conditions, but several successive great disturbances have obliterated so much of the original physiography and destroyed so many of the remains, that our knowledge is a mere outline. Some geologists believe that by far the greater portion of the anthracite deposits in Pennsylvania have been swept off by denudation, and may be now at the bottom of the Atlantic Ocean.

One of the geologic questions, allied to the problem of coal formation is the origin of petroleum and natural gas. Several theories have been advanced to account for these deposits. One suggestion is that the materials have been largely derived from vegetable organisms of comparatively simple type, which grow abundantly in moist places. Another opinion is that marine remains, especially fish, have been the source. Dr. J. M. Macfarlane, Emeritus Professor of Botany in the University of Pennsylvania, has lately published a book strongly advocating the latter view, but the subject cannot be further discussed here. Certainly, the gas and oil accumulations in different parts of the world constitute a most important source of fuel. The problem of securing control of such fields has entered into international relations and has become a seriously disturbing topic. We used to speak of pouring oil on troubled waters to still them, but oil of late has been continually troubling the waters of diplomacy.

When Charles II granted to William Penn, the territory that is now included in Pennsylvania, he imposed, as usual with royal gifts, certain tributes. Frequently these involved both nominal and real payments. The nominal payments were simply to maintain the principle that the monarch was the owner and had merely rented the territory or the privilege, and under his right of eminent domain could recall it, but the real payments were to inure to the benefit of his expense account. Charles obligated Penn and his successors to deliver yearly "at our Manor at Windsor" three beaver skins, and one-fifth of the "gold and silver oare found in

the Province." The beaver skins were easily obtained, but the region never yielded any appreciable amount of precious metals, although small amounts of both have been found. The coal, iron, oil and gas of the State have, however, been among the most valuable products of any part of the world and have been the foundation of the largest fortunes the world has ever seen.

INSIDE VIEW OF TERMINAL MORAINE, BANGOR, PA.

From Vol. Z, Second Geological Survey Pennsylvania.

Arctic Pennsylvania.

At a comparatively late period in the geologic history of the State, though probably long before the advent of beings who can be classified as human, the region suffered a change to an arctic climate. There may have been, indeed, several successive periods of this climate with intervening temperate conditions. During the cold period an ice-sheet nearly half-a-mile thick covered a considerable portion of the northern portion of the State, and of course, the larger part of the region to the northward and also extended westward. A period of such nature is known to geologists as a "glacial period."

Glaciers are ice-masses, formed from the accumulation of snow on mountain summits. If the summit is so low that all or most of the deposit made in the winter, is melted in the summer, a glacier will not be formed, but if the summit is above the line of perpetual snow, the successive falls will pile up on the mountain, and finally reach such a bulk that the under portions of the mass will be compressed to ice, and in time the pressure will become great enough to cause the ice to move downward, filling the rifts and gorges on the mountain sides, and gradually reaching a point at which the onward movement (which is very slow) will be equal to the melting effect, and the ice will cease to advance, but will be converted into a river source. In this downward movement the ice will gather up many fragments, large and small, of rocks, and carry them onward. Where such rocks protrude from the mass so as rub against the sides of the rifts or valleys in which the ice is moving, scratches will be produced, or even deep grooves. Sometimes the ice-mass passing over a tolerably high point will leave a boulder standing as evidence of its passing. The deposit of rock and dirt left at the point where the glacier melts is known as the "terminal moraine." In Pennsylvania, of course, all ice has long since disappeared, but the effects can be distinctly traced. A number of years ago, Henry C. Lewis, a Philadelphia geologist, explored the terminal moraine in the State, under the direction of the Commission for the Second Geological Survey, and his report published in Volume Z of the report of that survey, is liberally illustrated with photographs and maps showing the line of the moraine and many other data.

The line of the terminal moraine which marks the limit of the ice, enters the State about Belvidere, and turns to the northwestward. A little to the west of the center of the State it passes into New York State, but soon bends southward and runs down at such an angle that it makes its exit at the western border of Pennsylvania, at about the same latitude that it entered. The course of the terminal moraine is marked by deposits of earth and rock (till) often forming marked hills, and by deposits of boulders and by scratches and grooves on rocks. A great glacial groove is found on Table Rock at the Delaware Water Gap. Glacial scratches are found on the southern slope of Godfrey's Ridge, Monroe County. A boulder of conglomerate, nine feet in one dimension is found on the crest of Penobscot Knob in Luzerne County, at a point about

2000 feet above sea level. Penobscot Knob is only nine miles north of the terminal moraine, and its glaciation proves the great thickness of the ice near its edge.

Lewis' views of the character and extent of the ice-sheet are given in his report, noted above. That it must have been stratified is evident from meteorologic conditions. Every snowstorm added a new stratum to the top. Its whole thickness must have represented the separate snow precipitations of centuries. The top strata were loose, the middle strata more consolidated, the lower necessarily still further compacted, being in fact, converted into ice. A similar change in stratification is noted in the vertical edge of the great Antarctic glacier.

Continental snowstorms might cover the whole field with a new layer, but local or regional storms would increase the ice-sheet's thickness only where the fall occurred. The stratification of the whole sheet would be, therefore, irregular, but not so irregular as in Alpine countries, where as has been observed, snowstorms are localized and complicated with avalanches of masses of the different degrees of compression noted above. Such complications may have occurred in New Hampshire and Northern New York, probably not elsewhere.

On the other hand, we must look at the equatorial wind as the chief source of snowfall, inasmuch as at present we see the greatest rainfall and snowfall take place along the geographical belt where the equatorial wind meets, rides over and is chilled by the south-driving Polar wind, clinging to the surface of the ground, and the warm air drops the moisture through this cold wind. This would teach us that the ice-sheet must have continually grown thicker along that same geographical belt, namely, New England, the northern states and the lake region; in other words in that part of the sheet that lay for some hundred miles back of the terminal moraine.

The numerous storms of the Alps do not cover up, except in winter, the lower stretches of the longer glaciers, because the snow melts in summer, falls through the crevasses and issues below as a stream. The same condition prevailed in the American ice-sheet, all across the continent. The edge was an ice-cliff not a snow bank.

THE ROMANCE OF CHEMISTRY

Charles H. LaWall, Ph. M., Sc. D.

Dean, Philadelphia College of Pharmacy and Science; Professor of Pharmacy

PICTURE to yourself a room in an ancient monastery. The high vaulted stone ceiling, discolored with age, is but dimly visible. The only illumination is the light shed by a terra cotta lamp of early form and the glow from a charcoal furnace which is being used to heat a curiously shaped glass vessel called a "limbeck."

Kneeling by the spout issuing from the "head" or "capital" of the alembic, as it is now called, a bearded brother of an ancient monastic order, garbed in a coarse robe gathered about the waist with a rough cord, is seen intently watching a colorless, pungent liquid which trickles therefrom into another curiously shaped glass receiving vessel.

Scattered about the laboratory are implements and vessels of iron, copper, silver, glass, and earthenware. Parchment scrolls, papyri, stylus and ink for writing, litter a table which stands near. The air is acrid with the fumes of escaping vapors. The expression upon the face of the kneeling figure is one of rapt concentration and beatific satisfaction. On one of the sheets of parchment lying on the table we discern words written in an archaic, cursive Syriac script.

You have just witnessed, in your imagination, one of the early experiments in chemistry, perhaps one of the attempts to prepare the "Elixir of Life," or the "Philosopher's Stone"; perhaps the earliest distillation of "aqua vitæ," as brandy was at first called.

Contrast this secret and empiric search for the greatest *ignis fatuus* of all history, one in which the quest lasted for nearly 2000 years, with this more modern picture. We see an auditorium capable of seating hundreds of persons, crowded to the doors with well-dressed men and women of the highest intellectual types of our own times.

A leader among the modern workers in physical chemistry is standing back of an illuminated reading stand. Alongside is

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a table on which is a complicated model of spheres connected with wires, resembling an orrery or planetarium of medieval times. Indeed, the simile is apt, for the combination of spheres and wires is a hypothetical atomic model, and the lecturer has been discoursing upon the similarity between the newest concept of atomic structure and the arrangement of the sun and the planets in our solar system.

We hear the terms "alpha particle," "isotope," "nucleus," "quantum," "electron," "proton," "atom," and "molecule." The audience begins to have a faint conception or comprehension of the magnitude of the subject, but is in doubt as to the practical possibilities of such profound research. The lecturer calmly concludes: "And so, if we can succeed in splitting off or knocking out of place the eightieth planetary electron of the metal we know as mercury, by interatomic bombardment with alpha particles, we shall find that we have converted it into gold," and lo! the centuries have shrunk to nothingness, the scroll of time has rolled up.

The shades of philosophers and alchemists of ages past seem to have assembled for a roll call and approval of their labors. Thales, Anaximander, Leucippus, Democritus, and Empedocles of the early Greek school; Pliny and Lucretius of the Roman; Geber, Rhazes and Avicenna of the Arabian; Albertus Magnus, Roger Bacon, Raymond Lully, Basil Valentine, Paracelsus, John Dee, and Cagliostro of the later European period—all seem to have come back in spirit, and one instinctively thinks of Kipling's lines:

> "After me cometh a builder;
> Tell him I too have known."

Back through many centuries stretches the fascinating trail of man's effort in the direction of understanding the composition of matter and turning his knowledge to some practical advantage. The milestones on this trail are the discoveries that have been made—discoveries whose value has sometimes remained unrecognized for centuries. The landmarks on this same trail are the failures that have made possible a fresh start, or which have contributed by-products of unexpected value and entirely foreign to the quest itself. Today, when a new chemical compound is dis-

covered, steps are immediately taken to ascertain what possible value it may have in the arts, in the industries, or in medicine. Contrast this with the past procedure.

In 1540, Valerus Cordus, a noted pharmaceutical worker and writer, first prepared the volatile liquid which he called "oleum dulce vitroli," and which we now call ether. Three hundred years elapsed before the true value of this discovery was recognized, and the practice of surgery revolutionized by its employment as an anesthetic.

Formerly it took years, decades, and centuries for scientific observations and statements to find their way to the lay mind. When Vitruvius, the celebrated Roman engineer, during the reign of Augustus Cæsar recommended that pipes of earthenware and not of lead be used for conducting water, his reasons were based on the fact that lead workers or plumbers (*ab artificibus plumbarius*) suffered from chronic illness. It took more than a thousand years for the wisdom of his warning to be disseminated and heeded. How different is the case today! A few weeks ago when the gasoline improver, tetraethyl lead, caused the death of a number of workers in a research laboratory, the whole world was informed within a few hours of the dangerous character of the product in its concentrated form, and steps were immediately taken to minimize its dangers.

The accuracy of some of the measurements and the keenness of some of the observations of early Egyptian and Grecian astronomers and philosophers contrasts sharply with the stupidity of their speculations regarding the constitution of matter, which is the main province of chemistry.

About the time that Nebuchadnezzar was eating grass in Babylonia, Thales, the Greek philosopher of the sixth century B. C., attained the distinction of being the first example of an absent-minded professor by walking into a pool while raptly observing some celestial phenomenon. Thales is the first individual on record to have suggested the unity and indestructibility of matter. These views were also held by Anaximander, one of his contemporaries, who conceived, in addition, of an undetermined primal unit, the apeiron, which he assumed to be eternal in character and unlimited in extension.

Heraclitus, a successor of these two philosophers, believed fire to be the primeval element, to which Empedocles later added earth, air and water, making the quaternion, which lasted for many centuries as the basis for philosophic speculation. In later years some added salt and sulphur, others oil and spirit, and still others mercury, but no one seems to have even approximated the truth as exemplified in the modern ideas of chemical elements having relationships of mathematical certainty. Democritus, the "Laughing Philosopher," had theorized concerning what he called the atom, but there is a wide variance between his metaphysical notions and the atomic theory of Dalton.

These differences are not realized, however, when one reads Lucretius, the Roman poet of the first century A. D., who in his *De Rerum Naturæ* utters these remarkable lines:

> "That you may know
> That forms dissimilar coalesce in one,
> And things are formed of differing elements;
> As in our verse you many letters see
> Common to many words, yet words and verse
> As wholes dissimilar . . .
> This common atoms may exist in things
> The compound whole be yet dissimilar."

Matter is what concerns the chemist most. Even the wildest speculations of the philosophic mind from the time of Tut-Ankh-Amen to Sir Oliver Lodge were hardly prepared for the real facts as they seem to be demonstrated by the physical chemists of the past decade. Earth, air, fire and water did not satisfy the requirements for elemental substances after three of these had been found to be complex in themselves, and the fourth to be a manifestation of energy. The molecule for a long time had come to be regarded as a hard sphere made up of atoms of indivisible and untransformable character.

The mathematical consanguinity of the elements, as shown by Mendeleef's Periodic System and Newland's Octaves, forced the development of a belief that they were intimately related but stable as to their identity. The chemical theories and practices of the entire nineteenth century respected this atomic sanctity, but the discovery of radium, the charter member of the

elemental suicide club opened a new field of possibilities. Physicists who had for years been perfecting instruments of precision commenced to regard chemistry as worthy of some of their attention, and the most romantic chapter of science, the chapter which concerns itself with atomic and molecular structure, is now being written. Testing machines had been perfected with a compressing force of millions of pounds per square foot and yet so delicate in their adjustment that the slight pressure necessary to crack an egg shell could be measured by the same machine. Measuring devices are available for accurately determining the speed of light, which travels 186,000 miles a second. An instrument used by astronomers for measuring angular magnitude is capable of detecting an arc of one inch subtending a radius of 100 miles. A thermometer for making temperature measurements is so refined in its adjustment that the heat from the flame of a match held many feet away can be recorded. Balances are in use that are so sensitive as to detect the 1/30 millionth of an ounce, and when we consider the spectroscope, which is four million times as sensitive as the finest balance, and the electroscope, which is a million times more sensitive than the spectroscope, we seem to be nearing the limit of human possibilities in the direction of physical measurements. All of these instruments and others almost equally amazing have been marshaled to aid in unfathoming the mystery of the molecule and of the atom.

Before we go back over the earlier trail, let us see what the modern physical chemist tells us about the molecule and the atom, as we know them today. The almost incredible statements and comparisons which follow are quoted from the writings of contemporary scientists of recognized authority.

First, as to the molecule. It is molecules that form the mass of matter. A molecule is composed of atoms which may be similar, as in the case of elemental substances, or dissimilar, as in the case of compounds. Water is a compound. It is symbolized as H_2O; that is, it is composed of molecules, each of which contains two atoms of hydrogen and one atom of oxygen.

It will doubtless astonish many of my hearers to learn that the physical chemist can determine the number of molecules in

a given weight of many substances with greater accuracy than the census taker can ascertain the population of one of our large cities, and that the fixed weights of individual molecules and atoms have been determined to a closer proportionate degree than the average individual knows his own avoirdupois. If a single drop of water weighing a little over a grain were to be magnified to the size of the earth, the molecules would be only about the size of oranges.

A glass of water (about half a pint) contains ten million million million million molecules. We cannot grasp the magnitude of this number even when we see it written out in figures, so let us take another simile. If a single glass of water were to be dipped out of the ocean and then poured back, and if we can conceive of this original glassful of water being so diffused throughout all the oceans of the world that the distribution is absolutely uniform, and if we should then dip out another glassful, we should find about 2000 of the original molecules of the first glass of water distributed throughout the second one, if we had any means of recognizing them.

Molecules of matter are not tightly packed together, even in the densest substance known. They are separated from each other by great distances in proportion to their size, and are in constant oscillating or vibratory motion, with a speed greater than any rifle bullet. Collisions are so frequent between them that it has been estimated that each molecule collides with another one about five billion times in every second.

A single grain of gold can be beaten into a leaf or sheet seventy-five inches square. This sheet of metal will be only 1/400,000 of an inch in thickness and still will be many molecules in diameter.

So much for the molecule.

In the now popular crossword puzzle, when one of the initiated meets a four-letter word defined as "a small particle," the word atom is almost automatically written down. As has been previously stated, the atom of Democritus is not the same as the atom of Dalton, and we are quite sure that that eminent member of the Royal Institution who in 1808 gave to the world his "New System of Chemical Philosophy," would be astounded at the knowledge which the scientist of today has about this

smallest particle of matter. We are now informed that the atom, instead of being a solid structure, as once supposed, consists of certain "factors," as we shall call them, for so far as we can determine, they are not particles in the common acceptance of that term.

There are two of these factors only—the nucleus and the electron. The mass or weight of the atom is concentrated almost entirely in the nucleus. The electron is not matter at all as we know it, but is a manifestation of force. It has been described as a disembodied unit of negative electricity. The nucleus is supposed to be near or at the center of the atom, and gives to it its individuality. The electrons are spaced about this nucleus. Some physicists believe that the electrons revolve about the nucleus; others believe them to be in a state of violent commotion or agitation at some fixed distance from the center.

Take hydrogen, for example, the simplest and lightest atom known. It consists of a single electron and a single nucleus. The nucleus in the case of the hydrogen atom is called the proton. All nuclei are charged with (or may consist of) positive electricity. All electrons consists of negative electricity. The balance between these forces is the cause of the stability of the atom.

We cannot draw a diagram of the hydrogen atom to scale, for if we magnify the nucleus to a size that would be large enough to be seen by the naked eye, the electron would have to be magnified to about ten inches in diameter, and would have to be placed three hundred miles away to be in relative proportion as to distance.

Another illustration may help us to visualize atomic size and structure. Suppose an inch square of graphite were to be enlarged until it occupies a space equal to the entire orbit of the earth. This would make it 190,000,000 miles in diameter. The nuclei of the atoms would then be over one mile apart; the nearest electrons (two in number) would be 300 feet distant, while the four outermost electrons (four in number) would be one-fourth mile away.

All modern concepts of matter show it to be astonishingly open in structure. Does it not stagger the imagination? Composed of units of force only and as empty as the solar system,

and the individual atoms so small that 5,000,000 atoms of helium, the next in size to the smallest, could be placed in a straight line across the diameter of the period ending this sentence.

And now come other physicists, who have been experimenting with sensitive microphones, and who tell us that they can hear the rushing of the atoms and molecules to arrange themselves in the "lines of force" when a piece of iron is subjected to the action of a magnet. We may yet hear the music of the spheres. The ancient philosophers never dreamed of anything so fantastic as the truth itself.

The same electrons of which we have been speaking are the units of force which produce electric phenomena. In the electric lamps which light the room we are now in, electrons are passing through the incandescent filament at the rate of 300,000,000,000,000,000 a second.

All of the known facts regarding atomic structure have been considered in connection with certain mathematical relationships with the result that we now know that the number of chemical elements is limited to ninety-two, all but five of which have been discovered and identified.

Chemistry, according to etymologists, is derived from the root word "Khem," the native name of Egypt, where the science had its earliest recorded start. As this root word means "black," in reference to the color of the rich soil of the country, chemistry had some literal warrant for being classed among the black arts in later days. It was originally called the "Hermetic Art," after the Egyptian, Hermes Trismegistus, and later the practitioners were called "Spagyrists," from a title coined by Paracelsus in the fifteenth century. At first a mysterious and occult art, later an empiric practice, it has developed into a science of the first magnitude. Requiring a profound knowledge of its theoretic concepts, its practical applications are so easy and so fascinating that many a high school pupil considers himself a chemist when he has learned the names and symbols of the more important elements and can carry out a few simple experiments.

Who was the first chemist, or rather "alchymist," in history? Some of the early writers claim to trace the art back to Adam, others to Tubal Cain, and still others to Shem, the son of Noah—

stating that the original form of the word was "Chem," and reasoning therefrom that the word alchemy was thus derived. Later historians did not fail to include Moses, for he proved his rank as an adept when he reduced the golden calf to a condition of potability and gave the children of Israel the first "gold cure."

Solomon, of course, was credited with esoteric knowledge concerning transmutation. Ophir, the alleged source of his supplies of gold, silver, precious stones, ivory, apes, and peacocks, was so far distant that his fleet required three years to make a return trip. These early higher critics state that so far as gold was concerned, Ophir was but a subterfuge, and that he had the gold carried there and back again in order to mislead the world as to its real source.

Hermes Trismegistus, or "thrice greatest Hermes," was probably an Egyptian priest who lived before the exodus of the children of Israel from Egypt, and before the building of the great temple at Luxor, the Valley of the Kings. By some he is identified with the Egyptian God Thoth. He must not be confused with the Hermes of the Greeks. The hermetic writings, many volumes in number, cover a considerable period of time and are not the work of one person. They are concerned with metals and alloys, glass and enamels, as well as the preparation of medicines. Alexander the Great is said to have discovered the tomb of Hermes near Hebron and found therein a slab of emerald, upon which was written in thirteen sentences the essential secrets of alchemy in metaphorical and allegorical expression. Hermes is alleged to have presented this jewel to Sarah, the wife of Abraham, and it was afterward lost for many years. The traditional wording of the inscription was handed down for many centuries as an inspiration for the search. We pay tribute to Hermes in our use of the word "hermetical" in reference to the closure of a vessel, such a seal being in conformity with alchemistic practice in the carrying out of certain operations or the preservation of valuable substances.

The technical secrets which were handed down through generations of metal workers, jewelers, painters, glassmakers, and potters, were not embodied in any treatises or works as yet discovered, but it is contended by several modern historians

that the Egyptian lore was in this way transmitted to the artisans of Greece and Rome and preserved during the dark ages in the monasteries and workshops of Italy, France and Spain.

We are not certain that the Egyptian metal workers believed in the transmutation or sought to accomplish it. They were clever in the knowledge of the metals of their time and had named a white alloy of 20 per cent. silver and 80 per cent. gold "Electrum," in the probable belief that it was a distinctive metal. They knew also that arsenic had the property of giving a white color to many metals and that copper could be given the color of gold by the addition of cadmium.

1. Ancient Distilling Apparatus. (Peter's Pictorial History of Pharmacy. G. P. Engelhard & Co., Chicago, Ill.)
2. Hermes Trismegistus.
3. Birth of the Philosopher's Stone. (Follies of Science, Dolton.)

Such Egyptian documents as have been discovered and preserved, having to do with these arts and practices, date from about the third century A. D., and are probably the ones referred to in an edict of Diocletian, who, in the fourth century, ordered all Egyptian books dealing with the making of gold and silver to be burnt. It is probably that the cleverness of the jewelers and silversmiths and goldsmiths in the matter of imitating metals was the principal causative factor in this decree. It will be remembered that Archimedes' dramatic discovery of the utilization of the principle of specific gravity in the differentiation of base and noble metals had its inception in the need

for proving the genuineness of the crown of King Heiro of Syracuse, in the third century.

The Mesopotamians converted astronomy into astrology, and it is their influence that probably led to the association of the planets with the metals which developed shortly after the Chris-

1, 2 and 3. Alchemistic Symbols.
4. Writings from Mss. of Dr. Michael Maier. (Follies of Science. Dolton.)

tian Era and which persists in names of elements and chemical compounds, even in our time. The original classification included electrum, the alloy of gold and silver, believed by the Egyptians to be a distinct metal. The coupling of heavenly bodies and metals was at first as follows:

Sun	gold
Moon	silver
Jupiter	electrum
Mars	iron
Venus	copper
Mercury	tin
Saturn	lead

When, in about the sixth century, electrum was found to be an alloy, tin was transferred from Mercury to Jupiter and the metal mercury, or quicksilver, which had been given no place previously, was transferred to Mercury.

This latter one is the only metal in which the name still applies without change. In the compounds of the other metals we still find names pointing to these early associations. Pharmacists and physicians still call silver nitrate "lunar caustic." Iron rust is still sometimes referred to under its former Latin name "crocus martis," and a pigment made from an iron ochre is known as "mars' red." Lead acetate or sugar of lead is sometimes Latinized as "saccharum saturni," and lead water as "aqua saturni," and red lead is called "saturn red." Copper acetate or verdigris is sometimes referred as "crystals of venus."

At the time of the fall of the Roman Empire, when the spark of scientific knowledge was almost extinguished, we are indebted to the Arabians for "carrying on," and providing continuity of effort which made the Renaissance possible. There are three names of importance in this period from the eighth to the twelfth centuries: Geber, Rhazes, and Avicenna, and Geber, of the eighth century, is easily the greatest of these. He is said to have taught in the College of Seville. His full name was "Abou Moussah Djafaral Sofi," and the third of these names is spelled more variously than even Shakespeare's, but is usually given as Geber. No less than 200 works are ascribed to him, most of which, being in Latin, are probably spurious and are certainly not originals. Some of his Arabic manuscripts have been discovered, not all of which, however, have been translated.

It was during the period in which Geber worked that the art of papermaking was brought to the West from Samarkand. The decimal notation acquired by the Arabs from a now-forgotten race in India was just beginning to appear in European litera-

ture, which was then in its darkest period. Charlemagne then reigned in France, which was noted for its ignorance, profligacy and misery. The schools of learning at Bagdad, Alexandria and Cordova were then in their prime. The cruelty, treachery and fanaticism of the Moslems did not prevent the development of some really great figures among them.

Geber is the reputed discoverer of sulphuric acid, nitric acid, and nitrohydrochloric acid. The titles of the treatises ascribed to him are usually symbolic or figurative, as "The Book of Royalty," "The Book of Balances," "The Little Book of Pity," "The Book of Concentration," "The Sum of Perfection," and the "Book of Oriental Mercury." The language of many of these works is so obscure and so full of fine-spun metaphysical discussions as to account for the etymology of the word "gibberish." A short example will suffice:

> "Establish the equilibrium, the parallel with the aid of fire of three degrees, namely, the incipient fire, the medium fire, the extreme fire, which melts the elixir; the solid will melt like wax and afterwards harden in the air. It will penetrate and be introduced like a poison. The result will conform to the operation if the substance is excellent. The operation will be only rapid with the preceding substance, it will be very solid, excellent, and very pure. Only one part will suffice for a million."

It was during the Arabian period that the oriental imagery cast its shadow over the language of chemistry. Metals were "killed," by heating in the presence of oxidizing substances, and then "revivified" by heating with a reducing agent. Thus, metallic lead, when heated in the air, is oxidized to litharge or lead oxide. If some of this litharge is then placed in a crucible with a few grains of wheat and heated, metallic lead again appears. The explanation is very simple from a chemical standpoint, but these early workers either did not know, or ignored the fact, that charcoal would produce the same result as the grains of wheat (which must be converted to charcoal for the reaction to occur), and so they mixed up chemistry and biology in a fantastic explanation of the facts.

Then, too, the liberation of a volatile solid by heat (sublimation, we now call it), as in the production of benzoic acid from

benzoin (in which the brown, unattractive looking, resinous mass yields beautiful white crystals upon heating under proper conditions) was likened to the blossoming of a flower, and so these sublimable substances or products were called "flowers," and we still have the term "flowers of sulphur" in everyday use, because it is purified by sublimation now just the same as was done more than a thousand years ago when the metaphor originated.

Albert von Bollstadt or Albert Groot, who, upon joining the Dominican order translated his name into Latin as Albertus Magnus and who was known as the "Universal Doctor," was a notable figure of the thirteenth century and became Bishop of Ratisbon. He was an indefatigable worker in all branches of human knowledge and was described in the Great Chronicle of Belgium, a century after his death, as *maximum in magia, major in philosophia, maximum in theologia, Doctor Universalis.* At the time in which Albertus Magnus lived, the Universities of Oxford and Cambridge had just been instituted, while the University of Bologna dominated the world of learning with its 10,000 students.

Albertus had probably become acquainted with several important works of the tenth, eleventh, and twelfth centuries—the *Mappa Clavicula,* which describes the testing of metals by the hydrostatic balance, utilizing the principle discovered by Archimedes, in a more scientific form; the *Book of Seventy,* which was believed to be a translation of one of Geber's manuscripts, and the *Liber Sacerdotum,* which concerns itself with colors, precious stones and minerals. The latter is a very important work, evidently based upon Egyptian tradition. It contains recipes for making alloys, for coloring metals, for soldering metals, for tinting glass, and making dyes, and also for the transmutation of metals and making imitations of precious stones. It is equipped with an Arabic-Latin lexicon for the use of translators and users.

The works of Albertus Magnus were given titles descriptive of their contents, as "Of Mineral and Metallic Things"; "Of Alchemy"; "The Book of the Philosopher's Stone." His language has the merit of being at least intelligible and he is the antithesis of Geber in many ways. He first used the word "affinity" to denote chemical combination. He named the metallic

sulphates "vitriols," and we still use the names "green," "white," and "blue" vitriol to describe the sulphates of iron, zinc and copper, respectively. He was a skilful, practical chemist, and was one of the earliest authors to intelligently describe the distillation of alcohol, which had, however, been known in a fairly concentrated form for some centuries.

Contemporary with Albertus Magnus is one who stands out as the greatest figure for many centuries—Roger Bacon, the first English scientist of importance. Roger Bacon was not so much a recorder and interpreter as an actual discoverer. He had the inspiration and the vision of the modern research worker, and according to the interpretations, by Dr. Wm. M. Newbold, of the Voynich Roger Bacon Cipher Manuscript, translated in part about five years ago, he was nearly a thousand years in advance of his time in the thoroughness of his scientific knowledge, which he had to conceal from his contemporaries because of the opposition of the Church to his work. He was a member of the Franciscan order and spent much of his life in Oxford and Paris, becoming acquainted with many great scholars and philosophers of his day. He cast aside much of the knowledge of his contemporaries as being naught but repetition of error. He had a knowledge of Latin, Greek, Aramaic, Hebrew, and probably of Arabic.

He was handicapped by living in a period when the oppression of scholarship by the Church had begun to be felt. In 1209 the works of Aristotle had been condemned and forbidden to be read or taught. Bacon was a fearless stigmatizer of pride, luxury, avarice, and other evils which were then prominently indulged in by Church dignitaries. In 1266 Bacon received a request from Pope Clement IV to transmit to him secretly copies of his writings. Bacon sent copies of his three greatest works, the *Opus Majus, Opus Minus,* and *Opus Tertius.* In 1277 he was tried and condemned by the Minister-General of the Order of Franciscans. Whether he was actually imprisoned or only forced into retirement is not quite clear, but it put a stop to his openly published labors, for his next, and last, acknowledged work was a theological discourse published in 1792, the year of his death. He was buried at Grey Friars, the Franciscan Church at Oxford.

Bacon's knowledge was not only profound, but his statements were prophetic of future discoveries. He was acquainted with astronomy and proposed to Pope Clement the rectification

1. Albertus Magnus. (Alchemy, Ancient and Modern. Redgrove; David McKay, Philadelphia.)
2. Paracelsus. (Follies of Science. Dolton. Pharm. Rev. Pub. Co.)
3. John Dee. (Alchemy, Ancient and Modern.)
4. Count Cagliostro.

of the Julian Calendar, which was deferred until the time of Pope Gregory, over 300 years later. He was acquainted with lenses and had probably used both the telescope and microscope. He predicted navigation without sails or oars, vehicular transportation without horses or other animals, and machines for flying in the air. He also described gunpowder, but made no claim for originating it.

Bacon is alleged by some to have believed in the transmutation of metals. It is more likely that works attributed to him, making extravagant claims in this connection, were the work of impostors, seeking attention for their writings by ascribing their authorship to persons of high standing, a form of deception frequently practised from the time of Dioscorides to the seventeenth century, and making the labors of modern historians and commentators doubly difficult. It was in the period between 1277 and 1292 that the manuscript discovered by Dr. Voynich was probably written in the effort to transmit to future generations through the medium of a cipher, the knowledge which he feared to give openly to the world of his time.

Shortly after the time of Albertus Magnus and Roger Bacon appeared another important work called "The Book of Fires." attributed to Marcus Graecus or Marcus the Greek. This work, which was a sort of techno-chemical receipt book of its day, deals extensively with inflammable materials and explosives for use in warfare. A formula is given for making "rocket" or "thunder" powder, in which one pound of sulphur, two pounds of charcoal, and six pounds of saltpetre are directed to be mixed together. Other proportions of these same ingredients approximate the composition of gunpowders and pyrotechnic mixtures employed today. Gunpowder was first used in warfare in a crude and clumsy way at the battle of Crecy in 1346.

This "Book of Fires" also concerned itself with other interesting operations, as the following quotation will show:

> "Take best old wine of any color whatsoever in a cucurbita and alembic with joints well luted and distil with gentle fire. That which distils is *aqua ardens*. Its virtue and property is such that if a linen cloth is dipped in it and kindled it will give a great flame. When this is consumed the cloth will remain entire as it was at first."

Albertus Magnus had verified the fact that by "sublimation" of wine there is produced a light, inflammable, supernatant liquid, and Arnold of Villanova later refers to the uses of this *aqua ardens* in medicine and also calls it *aqua vini,* and mentions that still others have called it *aqua vitæ.* The name "alcohol" seems not to have been commonly used until the sixteenth century, when it was frequently employed by Paracelsus.

Thomas Aquinas, the greatest of scholastics, a pupil of Albertus Magnus, differed from his preceptor in that the few writings which he left are almost unintelligible—much in the style of Geber. He first used the word "amalgam" to describe the combination of mercury with a metal.

Another contemporary of Albertus and Bacon was a French Dominican, Vincent DeBeauvais (*Vincentius Bellovacensis*). He is distinguished for having made the greatest compilation of knowledge of the preceding ages. It was called "The Great Mirror" (*Speculum Majus*) and comprised eighty books with nearly ten thousand chapters, and references to nearly 500 early authors. This work was not published in its entirety until 1473, nearly two centuries after his death.

About the time of Albertus Magnus, Thomas Aquinas and Bacon, Marco Polo, the Venetian explorer, was preparing his famous travel talks on the Orient, and had just reached Pekin in 1270, the first European to bring back authentic information from the land of silks and golden dragons.

Raymond Lully, a Spanish scientist and mystic, who in his youth was a courtier and man of pleasure, later a religious zealot and missionary, founded a new philosophy, for which he was denounced as a heretic. After his death, as a martyr, for he was stoned to death by the Tunisians whom he tried to convert, he narrowly escaped beatification as a saint, and his relics worked miracles in Majorca and colleges were founded in different parts of Europe for teaching his philosophy. As the last and contrasting scene in this eventful history, his fame has been handed down as an alchemistic adept who discovered the elixir of life and prolonged his age for centuries.

Lully was the author of 486 treatises, most of which were upon literary, moral, metaphysical and theological subjects. About seventy, however, concerned themselves with medicine or

chemistry. He was probably a pupil of, or was inspired by Roger Bacon. Lully is the subject of one of the most interesting traditions in chemical literature. He is said to have been invited by Edward II of England to visit his realm, which he did, and was introduced to the King by John Cremer, Abbot of Westminster. Edward, under pretense of doing honor to Raymond, gave him an apartment in the Tower of London and then commanded him to replenish the royal coffers by the exercise of his alchemistic art. Tradition goes on to relate that he transmuted, at the King's behest, enough base metal into gold to enable the coinage of six millions of gold nobles. The coins issued at this period are known to antiquarians as "Rose nobles," and their assay proves them to be of purer gold than any other gold coin made in those early times. It is further stated that Lully was so beset to continue this work that he had to leave the Tower secretly and flee the country.

There are chronological discrepancies in the details of this story which impair its credibility, but there are several interesting sidelights which are a matter of actual record, and which serve to illustrate the belief in the possibility of such transmutation that was evident in high places. One of these is the fact that in Lully's last will and testament he refers to the incident that he had converted 50,000 pounds of base metals into gold. Another is that some years later, Henry IV then being King, the following statute was passed: "None from henceforth shall use to multiply gold or silver or use the craft of multiplication; and if any the same do, he shall incur the pain of felony." This statute was repealed by Henry VI, who ventured to replenish his coffers by "alchymy," and his statute discusses the feasibility and virtues of the philosopher's stone, encourages the search for it and dispenses with all statutes and prohibitions to the contrary.

This drew forth so many offers of aid and the responses were so encouraging that the King later published a message to his subjects informing them that the happy hour was drawing nigh when he would pay all the debts of the nation in real gold and silver. It served to attract to the court a miscellaneous rabble of impostors almost equal to that attracted to the court of Rudolph of Bohemia at a later period. Henry issued three

subsequent decrees authorizing the search for the philosopher's stone. In one of them he specifically includes priests because of their familiarity with miracles.

One of the charges brought against Protector Somerset at about this same period was that "You commanded multiplication and *alcumestry* to be practiced, thereby to abate the king's coin." Lully's principal chemical work was called the *Clavicula* (little key), which is couched in mysterious and for the most part unintelligible language.

Arnold of Villanova, of French or Spanish origin, was a contemporary of Lully. He was a theologian, a physician, and an alchemist. He wrote a number of alchemistic books with fanciful titles, among which were the *Speculum Alchemiæ* (the Mirror of Alchemy), the *Perfectum Magisterium* (the Perfect Master), *Scientia Scientiæ* (the Science of Sciences), and *Rosarium Philosophorum* (the Roses of the Philosophers). He was condemned as a heretic and fled to Sicily. After his death a number of his books were condemned and banned by the Church.

His alchemical writings are characterized by their obscurity and charlatanry. His medical works, especially those on poisons and on alcohol, are clearly written and very thorough for their time, although he had an exaggerated idea of the value of alcohol as a remedial agent.

An alchemistic mystery of the fifteenth century concerns a character named Basil Valentine. There have been so many conflicting stories about him and his writings that modern chemical historians are divided into two groups, *i. e.*, those who treat of him as an actual character and those who view him as a mythical personage. He is alleged to have been a Benedictine monk at Erfurt in 1414, and is said to have concealed his writings in one of the pillars of the abbey church, where they remained for years until a thunderbolt partly destroyed the church and revealed their hiding place. If all of the works attributed to him were concealed about the abbey, it would have required the whole church instead of a single pillar to hold them. His name is most prominently associated with antimony. It is said that having tried the effect of antimony upon the pigs in the neighborhood, without more than a fattening result, so far as he could observe, he tried it upon his fellow-brethren of the monas-

tery with such disastrous results that he named it "antimoine" (hostile to monks). He subsequently studied the subject further and embodied the results in a book entitled *Currus Triumphalis Antimonii* (the Triumphal Chariot of Antimony). The whole episode is open to question and the real authorship of the book is attributed to Johann Thölde of the early seventeenth century. Valentine is assigned to all of the centuries from the twelfth to the sixteenth, inclusive. The fact remains, however, that antimony is the name still given to this poisonous metal, although some etymologists trace its origin from the Greek roots "anti" and "monos," in recognition of the fact that it is never found alone.

By far the most picturesque and important character of those who, in spite of "errors enormous and manifold," added to the constructive knowledge of their times, was one grandiloquently called "Philippus Aureolus Theophrastus Bombastus von Hohenheim." There is no doubt or mystery about his existence. His portrait was painted repeatedly during his lifetime, notably by Rubens and Tintoretti, or pupils working under them, and he was the subject of numerous engravings and illustrations, often connected with attacks upon his standing and character. Robert Browning in one of his longer poems has pictured him as a visionary but sincere character, a dreamer who finds martyrdom in his idealistic strivings.

Paracelsus was born in Switzerland in 1493, and died in Salzburg, Germany, at the early age of forty-eight. During his short life he managed to upset the entire scientific world, leaving the historian with a multiplicity of conflicting impressions. His disciples extol him as a skilful physician, a wise teacher, a great reformer, and a sincere, pious, and unselfish character. His critics accuse him of being a charlatan, an ignorant egotist, a drunken braggart, and a superstitious visionary.

It is certain that he traveled much in his early life and probably visited the Orient. His father was a physician of repute and probably encouraged him in his studies. There is no positive evidence that he pursued any systematic course of study or had ever received the degree of Doctor of Medicine. When, at the age of thirty-two, he returned to Germany, he at first went to Strassburg and was then invited to become city physician at

Basel, Switzerland, which position carried with it the functions of a medical professorship in the then famous university of that city.

He entered upon his duties enthusiastically. His first act was to formally burn the textbooks of his predecessors before his classes and to renounce the infallibility of Galen and other ancient worthies whose teachings had been accepted implicitly for more than a thousand years. His pupils were interested and delighted. His contemporaries and rivals were shocked and scandalized. He induced the City Council of Basel to pass an ordinance subjecting apothecaries to supervision, which brought upon him the wrath of this group. He not only did not believe in transmutation but attacked the alchemists for pursuing such a foolish quest and directed them to turn their attention toward the search for remedies for disease. He acquired local fame by a number of marvelous cures. He was a voluminous writer, drawing almost entirely from his own experience and observations, as he read but very little. There are 234 publications ascribed to him, the majority of which are undoubtedly authentic. He had a clear and forceful style of expression. He believed that life was essentially a chemical process and stimulated the use of chemical substances as remedial agents, animal and vegetable drugs having held undisputed sway for thousands of years. He founded what has come to be known as the iatrochemical period, or the period in which chemistry and medicine were brought together. His death, it is said, was hastened by the effect of injuries inflicted by assassins in the pay of the orthodox medical faculty.

Paracelsus is the first of the prominent characters, whom we have considered, to profit by the advent of printing, which had its beginning during his father's time. Then, too, he lived in a period when the spirit of exploration was manifested in the voyages of Columbus, DaGama, Magellan, and others, and the spirit of revolt was exemplified by Luther and Erasmus, who were contemporary with Paracelsus.

Paracelsus is called by the "Encyclopedia Britannica" the pioneer of modern chemists and the prophet of a revolution in science.

John Baptist van Helmont was born of a noble family in Brabant in 1557. He was educated at Louvain and became emi-

nent in mathematics, medicine, and chemistry. He spent much of his life in chemico-physical experimentation. He was the first authority of note to dispute the elemental character of earth, air, fire, and water, which even Paracelsus had accepted with some modifications and additions. He originated the word "gas" and describes carbon dioxide very accurately and thoroughly, calling it "gas sylvestre," or "the gas that is wild and is found in out-of-the-way places." He believed in the philosopher's stone and claimed to have witnessed successful transmutations. He also sought ineffectually for another of the alchemistic myths, the "alcahest" or universal solvent. The illogical character of this quest seemed never to have occurred to these futile seekers. What would they have preserved it in had they discovered it, if it had the property that was claimed for it of instantly dissolving everything with which it came in contact?

We have taken but a hasty glimpse in the brief sketches of some alchemistic workers from the eighth to the fifteenth centuries, of but a few of the leaders, those who in spite of error had passed on to future generations something of value concerning the science in which they worked. Ben Jonson, in 1610, published "The Alchemist," one of the satires for which he was famous. Cowley, at about the same time, wrote: "So though the chemist his great secret miss (for neither it in art or nature is) yet things well worth his toil he gains; and does his charge and labor pay, with good unsought experiments by the way."

Nearly a hundred names of those who must be considered as sincere even if misguided searchers, are recorded in the period that we have covered. We have considered only about a dozen of these and we have left untouched episodes of interest and personalities unusual enough to make a number of lectures like the present. We stand aghast at the literary output of these ancient worthies. Without stenographic help or the convenience of the typewriting machine, and with printing in its infancy or even before its advent, these old masters of ancient art wrote scroll upon scroll and tome after tome. With crude laboratory equipment which could be surpassed in any high school chemistry department of today, they made discoveries of great moment and observations which were to become the foundation stones of a mighty science. It must not be thought, however, that all of these laborers were sincere, or that charlatans and

impostors did not take advantage of the wonderful possibilities in such a quest.

In the time of Queen Elizabeth, when a new world across the sea was beginning to claim the attention of adventurers and statesmen, the Court of Rudolph of Bohemia was the scene of the greatest assemblage of savants and swindlers, alchemistic tricksters, and scientific mountebanks ever known. Rudolph II, born in 1552, son of Maximilian II of Germany, nephew of Philip II of Spain, was at first King of Hungary, later also King of Bohemia, and in 1576 succeeded to the throne as King of Germany. He moved the capital from Vienna to Prague, cast the entire responsibilities of his titles upon his ministers and executives and devoted himself with great zeal to the accumulation of art treasures and the cultivation of science, not the science which we know today, but the lunatic fringe which included astrology, magic, and the baser sort of alchemy.

In a short, narrow street of Prague, known as "Gold Alley," lived the occultists and spagyrists. These came from all over Europe, attracted by the liberality of Rudolph, who entrusted much of the detail to Dr. Von Hageck, the director of his laboratories. Among the ingenious frauds and impositions detected and described by Dr. Von Hageck were the following:

Some used double-bottomed crucibles, the false bottom being fusible and containing gold, which would appear in the flux after the operation. Others employed hollow tubes for stirring the ingredients, the gold being secreted within and the bottom being stopped with wax, which melted and allowed the gold to mix with the contents of the crucible when the apparently solid rod was used for stirring purposes. One adept had saturated a piece of charcoal with a solution of a gold salt and mixed this with the plain charcoal employed as a reducing agent in the flux itself.

Among the interesting characters who joined the hundreds drawn to Rudolph's court were the astronomers, John Kepler and Tycho Brahe. Kepler wrote several of his most famous astronomical works while at Prague and enunciated the principles which are still known as Kepler's Laws. Tycho Brahe was a Dane who was known as "the man with the silver nose." His nose having been severed in a duel was cleverly replaced with a metal nose which was cemented in place. Brahe, although he

made several important astronomical discoveries which assured his fame to future generations of scientists, was more of an astrologer and occultist, superstitious to a degree. These two were not connected with the alchemistic rodeo, but another notable pair of international humbugs whom we shall now discuss spent some time there.

We may be doing John Dee an injustice by referring to him in this derogatory manner, but he certainly risked his reputation when he associated, as he did for some years, with such an acknowledged rascal as Edward Kelly. Kelly was not even his real name. He came to Oxford as Talbot, but left under a cloud and was later pilloried in Lancaster for forging title deeds and coining base money. After other unsavory episodes he associated himself with John Dee in 1582, when he was about twenty-seven years of age.

In 1584 Dee and Kelly joined the motley throng at Prague and were established by Dr. Hageck in his own house, situated near the celebrated Rathhaus, whose clock tower, built in 1484, still stands, and not far from the University, established in 1383, in whose halls John Huss had started the disputations that led to his martyrdom by the Council of Constance.

Kelly's hold upon Dee seems to have been concerned with a mystical manuscript and a vial of unknown powder, supposed by them to be the philosopher's stone. Kelly had unearthed these treasures in the ruins of Glastonbury Abbey. Kelly was also a "skryer" or descrier of images or visions in a crystal ball, and Dee had a celebrated crystal ball or "shewstone," which gave to Kelly an outlet for his talents. It was Dee's shewstone that had first interested Queen Elizabeth, although it is not of record that he or his skryer saw the vision of the defeat of the Spanish Armada which took place during this period.

The first experiment by these two adventurers at Prague was privately performed in the house of Dr. Hageck, when, by the mediation of a single drop of a red liquid Kelly "transmuted a pound of mercury into excellent gold." The report soon spread and Kelly was knighted and created Marshal of Bohemia. His inability to repeat the experiment when commanded to do so by the Emperor placed him in an embarrassing position and he was imprisoned twice. The second time he murdered one of his guards in an attempt to escape and avoided the death pen-

alty by claiming the protection of Queen Elizabeth, which was accorded him. His continued incarceration led him to attempt another escape in which he was killed by a fall from his prison window.

Dee, in the meantime, had returned to England, where he was received by Queen Elizabeth and granted a license to practice alchemy. Dee had previously obtained the favor of the Virgin Queen by instructing her in alchemistic lore and in the uses of the shewstone. Dee's laboratory and library, after his return to England, were augmented by many books and instruments which he had collected on his journeys. He possessed thousands of rare books and manuscripts and scientific instruments of unique character and rarity. Dee himself was an indefatigable author whose books poured in a continuous stream from his facile pen each year from 1547 to 1583. He introduced algebra into England and was the first English author to use the now commonly employed signs for plus, minus and equality.

Dee's diary, a number of his printed works and a few of his crystals and instruments are preserved in the Bodleian Library and the British Museum. It is probable that he was sincere but misguided, but in the latter classification could be numbered many who occupied high position in his and in the succeeding century. We do know that, in spite of his unquestioned attainments and ability, he left nothing of constructive value in his writings.

One more character must be considered, comparable to Dee in many ways, although of a period two centuries later. Cagliostro is the *nom de guerre* of an individual believed to be identical with Guiseppe (Joseph) Balsamo, a Sicilian swindler of the latter part of the eighteenth century. "Count" Cagliostro, as he called himself, appears prominently for the first time in 1776 in London in connection with a Masonic organization called the "Order of Strict Observance." He next devised a new secret society which he called Egyptian Masonry, which was to reform the entire world. He claimed to have the power of transmuting metals, of a miraculous healer, and to be the possessor of the Elixir of Life. He figured in many court intrigues and scandals in various European capitals, the most notable of these being what historians call "The Diamond Necklace Affair," in

connection with which he suffered imprisonment for a time in the Bastille. Surrounding himself with an air of mystery and affectation, he was credited by many with having in his possession the secret of continuing his existence through many ages, and to have had a history and experience comparable to that of the Wandering Jew.

Apparently possessed of great wealth of mysterious origin, he passed through the period from 1776 to 1789 like a meteor, and finally passed out after conviction by the Inquisition and imprisonment for life. When the battalions of the French Revolution entered Rome and attempted to release the entombed adept by force, they were informed that Cagliostro was dead. The familiar spirits, who had summoned the shades of the departed at many notable seances at his behest in Paris in the days of his glory, seem to have deserted him, and the illustrious proprietor of the "Grand Magisterium," as the philosopher's stone was sometimes called, died in loneliness and want.

A catalogue of alchemistic literature appearing in printed form from 1514 to 1739 comprises nearly 1000 titles and nearly half as many authors. We have entirely omitted reference to the Rosicrucians, with whom we could spend an entire evening, but they belong more in the classification of the Romance of the Occult, which may make a later chapter of this series.

The period of the Renaissance included several other important characters besides Valentine, Van Helmont and Paracelsus, whom we have briefly discussed. Georg Agricola was the famous metallurgist whose great work, *De Re Metallica,* served as a working manual until comparatively recent times. Johann Rudolph Glauber, whose name is associated with sodium sulphate, which we call "Glauber's Salt," and use mainly in veterinary medicine, believed that in this compound, which he obtained by the evaporation of the waters of a well-known German spring, he had found a panacea for all human ills, and called it *Sal mirabile,* the miraculous salt. He was the father of industrial and engineering chemistry.

The period of modern scientific chemistry began with Robert Boyle (1627-1691). Romance is not lacking, however, as scientific development proceeds. The erroneous phlogiston theory, enunciated by Stahl in 1717, was based upon the assumption that

a fire-substance, *phlogiston,* escaped during all forms of combustion. This theory held undisputed sway until 1772, when it was logically disproved by the brilliant researches of the ill-fated Lavoisier, the father of quantitative chemistry, who was guillotined in 1794 by the French Revolutionists, and of whom it was said at the time that "It took them but a moment to cut off that head, though a hundred years, perhaps, will be required to produce another like it."

We must not forget the epoch-making discovery of oxygen by Joseph Priestley, whose apparatus consisted of a few bottles and tubes, and an old gun barrel, of which he quaintly says, to account for certain failures in his experiments: "A good deal will also depend upon the ingredients which have been used in the gun barrel in preceding experiments, for it is not easy to get such an instrument perfectly clean from all the matters that have been put into it."

And then, too, there is Karl Wilhelm Scheele, the humble Swedish apothecary, who became eminent through his discoveries of many important substances, among which were the organic acids (citric, tartaric, and oxalic), the deadly hydrocyanic acid, or Prussic acid, as it was at first called because it was made from Prussian Blue; chlorine and oxygen, the latter discovered independently by Priestley. Scheele became so famous outside of his own land before his ability was recognized at home that when the King of Sweden, while traveling in foreign parts, heard of this remarkable scientist in his own kingdom, he sent word back for Scheele to be honored, but alas! he was so obscure that another person of the same name was knighted by the prime minister, much to the recipient's bewilderment and surprise.

The chemical revolution begun by Lavoisier was continued by Berthollet and culminated in the atomic theory by Dalton. Dalton was a versatile scientist who made the first systematic study of color blindness and who was one of the earliest students of meteorology. Dalton's conception of the atom differed from the primitive ideas of the early Greeks in that it had a mathematical basis which, after some minor corrections due to more accurate quantitative determinations, was so sound that it served for a century's marvelous development of both theory and practice. Dalton would not recognize the atom of Rutherford, Bohr,

and Langmuir, but the newer knowledge is not incompatible with the older, being but an amplification of detail. We are not discussing chemical theory, however, but the unusual incidents which illumine the pages of what to some is a dull, drab physical science.

Sir Humphry Davy, the discoverer of a number of chemical elements and the inventor of the safety lamp as used in coal mines today for diminishing the danger of explosions, made his greatest discovery when he engaged Michael Faraday, for it was the latter's studies on electricity and magnetism, one hundred years ago, that made possible the electric light and the dynamo, but the unusual touch is found in the fact that Faraday originated the words "electrolysis," "anode," "cathode," "electron," and "ion"—words which have just come into their true heritage of usefulness within the past few decades.

The nineteenth century, the age of the world's greatest material and mechanical development, still furnishes instances of workers who, searching for one thing, find another. If, when the youthful W. H. Perkin, later knighted for his discoveries, had found the synthetic quinine which he sought in 1856, the secrets of the tar barrel might not have been unlocked for another generation, and if the chemicals with which he was working had been of the purity that he believed them to be, the first coal tar dye would not have shown its purple hue in his test tube, for when he tried to repeat the experiment which revealed the dyestuff known as "mauve," he failed for a time because one of his reacting materials in the original work had been contaminated with an impurity of whose presence he was unaware.

If we had time and space we might go on indefinitely with interesting illustrations of unusual events or facts connected with chemistry. We can at least, however, appreciate the possibilities in sight and in our vista be reminded of the lines of Dante Gabriel Rosetti:

"Nay, come up hither. From this wave-washed mound
Unto the farthest flood-brim look with me;
Then reach on with thy thought till it be drown'd.
Miles and miles distant though the last line be,
And though thy soul sail leagues and leagues beyond—
Still, leagues beyond those leagues, there is more sea."

CHEMISTRY AND COLOR

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COLOR may be thought of subjectively, as a sensation perceived by the eye. We may say that the color of a substance is one of its inherent properties, and be content with this explanation. The ancients were, but we moderns are more curious, and like to know why we see things as we see them.

The perception and the appreciation of color in nature antedates all scientific knowledge. Throughout the ages, the different greens of foliage, the blue haze of distance, the riot of colors of the flowers of the field, the gorgeous tints of autumnal landscapes, the azure of the sky and of deep waters, the silver and gold and lilac and rose of the clouds at sunset, have gladdened the human heart, and inspired poetic emotions. Not until Sir Isaac Newton made certain experiments with prisms and sunbeams, did anyone suspect a connection between the rainbow and other color phenomena in nature.

The color-charms which man perceived and admired in his surroundings, he attempted, at an early date, to appropriate for personal adornment, and for the purpose of beautifying his household furnishings. Colored pebbles are cherished by the most primitive tribes. Colored earths, and colored ores, mixed with animal fat, provided the first paints. Stains, obtained mostly from vegetable sources, have since time immemorial served to make human habiliments more pleasing to the eye. The ruins of Persia, of Egypt, and of the palaces of Cnossus, have disclosed evidence of the appeal which colors made to the nations of the past. Joseph had "a coat of many colors."

Old Timers.

For a long, long time progress in the knowledge of colors consisted in learning how to select and use the pigments and stains provided by bountiful nature. How to prepare and mix such pigments, how to develop and apply the stains which by accident had been

found to be available, engaged the attention of the craftsmen. Much empiric knowledge accumulated. And some is very old. The Egyptians knew and used some of the dyes which are in use today, a fact discovered when the fabrics from ancient tombs were examined by modern scientists.

When the ruins of Pompeii were exposed to view, there were found, near the Pompeiian dye houses, heaps of shells of a snail-like mollusc, a secretion of which provided the Tyrian purple, the brilliant coloring matter used to dye the robes of the aristocrats of that distant day. And Pliny tells us that when the ancient Britons sallied forth to battle against the Roman invaders, these savage warriors fought in their war paint—a deep blue stain applied to their faces and bodies. More recent writers identify this stain as woad, a dyestuff obtained from Isatis tinctoria, a plant of the mustard family; and they derive its name from Woden, the deity of the ancient Saxons. We now know that this blue substance can be developed from a variety of plants, notably from the indigo plant of India, which had been in use for centuries by the nations of the East before the advent of the invasion of the British Isles. We know also that the blue dye of the ancient Britons, and the blue of the Roman invaders, as well as the blue of old Egypt, are identical, though obtained from different plants, and from different localities. It is, indeed, the same blue dye which is in use today, namely, indigo. This indigo is a definite chemical compound, always exhibiting the self-same properties, regardless of its origin; and the modern chemist can make it from a substance separated from coal tar.

Another ancient vegetable dye is Turkey Red, obtainable from the root of Rubia tinctoria. When, about 150 years ago, the descendants of the ancient Britons contested with the troops of Washington for the country in which we live, red was the dominant color of the British uniform, and Rubic tinctoria provided the dye. To be sure, many other vegetable colors were in use also—yellows and browns and blacks. But indigo, and Turkey Red, also called madder, were the principal colors of many nations, in war and in peace, and these dyes occupied this place of prominence for a long period. Turkey red, like indigo, is used in great quantity today. As in case of indigo, the chemical make-up of Turkey red is known; so this substance also may now be manufactured artificially, by the processes of synthetic chemistry, from something which is found in coal tar.

Even Tyrian purple, the royal purple of the ancients, can be synthesized by the chemist. The only reason why this is not done commercially is that we have superior red dyes of coal tar origin with which the dye of the ancients, laboriously developed from the secretion of molluscs, cannot compete.

Dyes from Coal Tar.

Not only has chemistry shown the way to the duplication of the coloring matter from animals and plants, it has also brought about the production of a large number of chemical compounds which have no counterpart in nature, but which serve excellently as dyes. Indeed, more than a thousand coal tar dyes are now obtainable through the regular channels of trade, and procurable at a moderate price, so that brilliantly colored raiments are no longer limited to the adornment of the rich. And all these dyes, of all the colors of the rainbow, and their tints and shades, some permanent, others fugitive, some poisonous, others harmless and adaptable for food coloring, some which dye wool or silk, others for cotton, some to be used in one manner, others in quite another—all are made from substances found in coal tar! And all this development in synthetic chemistry has come within the memory of persons now living. It was in 1856 that a young English chemist by the name of Perkins, working on the synthesis of quinine, made some experiments with crude aniline, and obtained a mauve-colored substance. Some years later this accidental result led to the production of the first synthetic dye, which explains the popular name, aniline dyes, for coloring matters of this type, a name which has prevailed despite the fact that the great majority of coal tar dyes are not really aniline derivations.

What the development of these products has done to the industry based upon the utilization of vegetable and animal dyes, may be imagined. The cultivation of the indigo plant, of Rubia tinctoria, and of other dye-plants, no longer pays. Idle stand the vats where this color-producing material was macerated, fermented, and manipulated, *secundum artem,* while the business of making synthetic dyes is increasing in volume and in the diversity of its output. And as for the molluscs which provided the Royal Purple of Solomon and of Cæsar, those lowly creatures of the sea may now round out their full span of life undisturbed in the waters of the Mediterranean.

Yes, chemistry may be said to have solved the dye problem—solved it in a few decades, and rendered useless all the empiric knowledge which has been accumulated throughout the centuries. It solved the mystery of the chemical composition of the important dyestuffs of the past. It made possible their synthesis. And it added to this list, a thousand dyes which nature failed to provide, except potentially, in coal tar.

To duplicate synthetically a coloring matter of plant origin, it was necessary first of all to determine its chemical make-up—to find out what elements are present in the compound—in what proportions or ratios these elementary atoms are grouped in the molecule, and to ascertain the relative weight of the latter. In other words, the chemist had to determine what is known as the structural formula of the substance, a task which was impossible until the science of organic chemistry had reached a fair stage of development. In reaching this advanced position, chemists produced—or shall we say created—many thousands of new compounds, each of which was promptly examined as to its physical and chemical properties. Some of these, as for example trinitro-phenol, were found not only to exhibit color, but to have the property of clinging so firmly to fabric that water fails to remove them. It was, therefore, natural that such compounds should have been experimented with as dyes, and that those which stood the test should have been utilized in this capacity.

Chromophores.

When a considerable number of such chemicals had come under observation, chemists proceeded to generalize from the facts observed, and it was noted that certain types of compounds were apt to exhibit color, and that the introduction of certain groups of atoms was responsible for the development of this property. It was found that a certain arrangement of the atoms within the molecule produced a certain dye; and that a different arrangement produced a compound of a different color, or of a different tint or shade, or of no color whatsoever. All these observations were jotted down. Accordingly, the search for new dye compounds became progressively more scientific, and less empiric or haphazard. Chemists then began to speak of chromophores—meaning the atom groups upon which depends the color of the compound.

Mordants.

But it is not enough that the compound which is to function as a dye possess color. It must, as has been observed before, cling to the fabric, and not wash off. It must, moreover, be fairly resistive to the action of the atmospheric gases, and to the action of sunlight. If it does not possess these properties—if it is oxidized in air, or reduced by sunlight—it is, of course, too fugitive for practical use. And yet, there must not be perfect stability, for a certain tendency to oxidation, or to reduction, seems to be associated in a compound with that property which manifests itself as color. Hence it is that we can remove stains by the use of oxidizing agents, like bleaching powder, or with reducing agents, like sulphurous acid. These chemicals alter the chemical composition of the dye, producing colorless products, in the first case by oxidation, in the other, by reduction. Another interesting fact with reference to dyes, is that some fail to cling to certain fabric, as, for example, cotton, except with the intervention of a foreign substance, which, when thus employed, is known as a mordant. Alum, chrome alum, tin salts, and other compounds, are thus employed as mordants, and their use is not by any means limited to the dyeing with synthetic dyes, but is essential also when vegetable or animal colors are resorted to.

Now, it may be that a dye adheres firmly, without the help of a mordant to one type of fiber, like wool, but refuses to cling to cotton. That is to say, it exhibits a selective action. This fact is utilized in various ingenious ways by the scientist. If, for example, one places a drop of para-nitraniline hydrochloride solution on this paper, it will produce no conspicuous stain. If one drops the same solution on newspaper, it will develop a deep yellow spot. The reason is that the book paper is made of "chemical wood pulp," and is nearly pure cellulose, whereas the newspaper is printed upon stock made up largely of "mechanical wood pulp" from which the lignin, and other compounds natural to wood, have not been removed; and para-nitraniline seeks out the lignin, and stains it, while it refuses to stain cellulose. The practical microscopist uses a number of such stains which have selective action, and he is thus enabled to distinguish more clearly the different kinds of cells and tissues in his microscopic mount. Differential staining is used also in the technique of identifying micro-organisms, some of which "take" one kind of stain, while others have an affinity for a different stain—an

observation which, by the way, led Ehrlich to develop a new line of attack in combating certain diseases, namely, by medication with therapeutic agents of the character of dyes exhibiting a selective affinity for certain micro-organisms which may invade the human body.

To enumerate the common synthetic dyes, explain their chemical nature, and to give their characteristics, would carry us too far afield in the realm which belongs to the specialist. But it is an interesting fact that all synthetic dyes are derivatives of ring or closed chain hydrocarbons, like coal tar benzene, naphthalene, or anthracene, or of their homologues, no colors being obtainable from the open chain hydrocarbons, such as are found in petroleum. Yet all ring hydrocarbons are colorless, and color results only when a certain color-giving group of atoms, called a chromophore group, is introduced into the molecule. A number of these chromophore groups contain nitrogen, as for example, the nitro group, and the azo group. Some contain also sulphur, as in the thioazines, while one of the most important groups contains only carbon, hydrogen and oxygen. But the chemical composition of dyes is exceedingly complex, too complex for discussion in this lecture. Let us, therefore, pass on to another phase of our general subject.

Lakes.

Some dyes, as has been stated, can be made to adhere to certain fabrics only when a mordant is employed. Mordants are, speaking generally, compounds of metals, or are acids, and they appear to combine intimately with the dye, sometimes with the development of a different tint or shade or color. Now similar in some respects to the combination of dye and mordant is the chemical union of a dye with some other compound or compounds with the formation of a product which has more "body" than the dye itself, and which exhibits greater opacity. Thus is produced in fact, a kind of pigment, adapted for suspension in suitable media. Pigments made from dyes in this manner are called *lakes,* a name derived from *lac,* which in turn comes from *lakh,* a Sanskrit word harking back to a very ancient dye, known before the days of Moses, and obtained from a scale insect. This insect provides two distinct products, a varnish resin familiar to us in the form of shellac, and a coloring matter similar to that procurable from the Mexican cochineal bug.

Now lakh in the Sanskrit meant one hundred thousand, or a great number. Why this name should have been employed for a coloring matter, and also at a later date, in modified form, for a resin, becomes clear when we read that these insects, at certain seasons of the year, appear in countless numbers, and cover the twigs of trees and bushes very much like the San Jose scale covers fruit trees in this country. So it appears that the words lac, and lacquer, and the more modern term lake, have a common etymology.

Lakes can be made of vegetable or of animal dyes; but the majority of them are nowadays made from coal tar colors. These pigments combine the brilliancy and depth of color of such dyes with the body and the opacity of mineral pigments, to which, however, they are apt to be inferior in point of permanence. Lakes play an important role in color printing. Our colored newspaper supplement is printed with ink made from lakes. So is our wall paper; and so are calicoes and similar printed fabrics.

One of the best-known lakes of the older type is carmine, made from the coloring matter of cochineal, the name carmine being a corruption of the word Kermes, which is the name of the Asiatic insect previously referred to as one of the most ancient dye substances. Lakes are named, in many cases, by compounding the word lake with an adjective denoting a color, as for example, orange lake, crimson lake; or the name of a dyestuff may figure, as in indigo lake, madder lake, alizurine lake, ponceau lake, safranine lake, etc. Some have names of geographic significance, as, for example, Berlin lake.

The manufacture of lakes is a highly specialized industry, and has been brought to a remarkable degree of perfection, although the underlying science is still in a formative stage. Briefly, it may be said that some dyestuffs are acidic in character, and are combined with barium, lead, aluminum, tin, zinc or other metals, salts of which are employed in the production of the lake. Other coloring matters are basic, and are precipitated with acids, notably with tannic, arsenous, phosphoric, oleic, stearic, antimonous acid, and the like. A lake is sometimes given greater body and opacity, or changed in other respects, by being precipitated upon such insoluble mineral matter as, for example, barium sulphate, china clay, zinc oxide, aluminum hydrate, and even upon red lead, or lampblack, a process which is employed also in the production of certain modern pigments for the

paint industry, and which accounts for such products as American vermilion, a pigment quite different from true vermilion which is mercuric sulphide.

The transition from lakes to pigments—using the latter term with the connotation popularly applied to it—involves passing from very complex compounds to relatively simple ones.

Pigments.

The pigments found in nature may be colored clays or earths, like ochre, sienna, or Van Dyke brown, or they may be minerals of rather definite chemical composition, like orpiment, which is sulphide of arsenic. But by far the greater number are laboratory products—distinct chemical compounds, the manufacture of which is based upon the well-known laws governing chemical reactions. Some occur as by-products in the production of other compounds, as, for example, the red ferric oxide, which is the residue left in the retort when fuming sulphuric acid is made from pyrites.

In the early periods of human progress, only the pigments from colored earths and from colored minerals were available. Our American Indians were limited to such pigments, and their war paints, not counting the vegetable stains, were largely earths colored with oxide of iron, although the tribes of certain localities used also cinnabar and orpiment. But it should be remembered that there are chemical processes of manufacture which antedate by many centuries the era of scientific chemistry. Thus soot, as a black pigment, the forerunner of our lampblack, is found in the oldest of cave drawings, while a process for making white lead—a process almost identical with the Dutch process—is described in the writings of Diascorides, who was a contemporary of the Apostle Paul.

It is, however, true that most of our present-day pigments, those for artists' use as well as those for house paints, are relatively recent accessions, and that the palettes of our early painters exhibited a poverty of colors which would seriously hamper a modern artist. Chrome yellow, English vermilion, red lead, Prussian blue, Scheele's green, and scores of other pigments in extensive use by the industry which strives to "save the surface" and by this means to "save all," are products of the chemical laboratory, and their manufacture is now conducted on a large scale, with the employment of modern factory methods.

What Is Color?

But why, let us ask, is lead chromate yellow? Why is artificial mercuric sulphide red? Why does any dye or pigment exhibit the color we have learned to associate with it? Why do some substances possess color, while others are colorless? What, really, is color? The answers which science offers may not be wholly satisfying; but they provide a clue which may eventually point to a solution of the mystery. Let us consider another question: Is the color of a substance a specific property dependable upon the elements in a compound, and upon the ratios existing between the atoms of such elements? The chromophore hypothesis might lead us to infer this. But what shall we do with the following facts? Mercuric sulphide may be as black as soot; mercuric sulphide may also be scarlet, a variety known as English vermilion. Mercuric oxide may be yellow, or it may be bright red; and as far as a chemical analysis goes, the two varieties are identical. Mercuric iodide is scarlet, changes to yellow on heating, retains this color on cooling, but suddenly changes back to the scarlet substance when it is touched—say with a lead pencil point. Cuprous-mercuric iodide is red, changes to dark brown when heated to about 75 degrees C., and assumes its initial color, namely, red, on cooling, even though it be not touched or disturbed. Nor are such seeming vagaries limited to compounds of mercury. Every chemistry student knows that ordinary waxy phosphorus, which is virtually colorless, or of the color of very pale amber, may be changed to a variety of phosphorus maroon red in color, yet both varieties are phosphorus, an elementary substance. To be sure, these varieties of phosphorus have other points of dissimilarity besides those as to color; and the same may be said of the compounds mentioned.

Selective Reflection.

But the point is that we must look beyond the facts disclosed by the chemical symbol or formula for the clue which may lead to the solution of the riddle, why any given substance exhibits a certain color. So let us shift our attention from dyes and pigments, and briefly consider the subject of light, for in the absence of light no colored substance exhibits its color characteristics. What really is light? As early as 1668 Sir Isaac Newton had demonstrated the composite character of solar light. The artificial rainbow he succeeded in pro-

ducing was called the spectrum, a name which implies its phantom-like character, for these color effects proved to be as immaterial as a shadow; one can not dip a brush in them and transfer them to canvas. They are the spectral or ghost colors.

Since Newton's day science has demonstrated conclusively that light travels in waves which are transverse to the direction of the ray, that white light is composed of waves which differ in length, and that the light of which the human eye can take cognizance, is made up of waves ranging from about .33 to about .8 of a micron in length—and a micron is 1/25,000 of an inch. Waves longer than .8 of a micron are invisible, and are known as infra-red waves, or somewhat inaccurately, as infra-red light, while waves shorter than about .33 micron constitute ultra-violet waves, or, if you will, ultra-violet light. The X-rays are exceedingly minute as compared with light waves, while the waves tuned in by our radio, are vastly longer—city blocks in length.

Now it appears that our interesting and active little electron within the atom, by virtue of its activity, tunes in certain wave-lengths of the radiant energy which we call light, and refuses to tune in certain others; and the waves which are not tuned in are transmitted or reflected, and determine the color of a substance. Thus, a red pigment, it may be understood, tunes in all the wave lengths except those which give to the retina of the human eye the sensation of red color. A substance which reflects all the wave lengths, reflects without exercising selectivity, is white; one which absorbs all, without selective reflection, is black. But it should be understood that our common pigments do not reflect pure spectral hues, but mixtures of them.

At this point we may profitably try an experiment. Let us set fire to some wood alcohol which has been poured upon some common salt in an evaporating dish. As the wood alcohol burns, the heat generated volatilizes enough salt to tinge a distinct yellow the colorless flame first observed. If now we turn out all other light, and view in the glow of our sodium flame, fabrics dyed in all the colors of the rainbow, we find that only the yellow fabric shows its characteristic color, all other fabrics appearing black. In like manner, red lead looks black; so does chrome green; and also ultramarine and the violet crystals of chrome alum. But lead chromate, called chrome yellow, exhibits its color under the sodium flame.

Now the sodium flame is monochromatic light, which means that it is not composite as to wave-length, but is made up of waves of a uniform or nearly uniform length (about .59 microns), and only the lead chromate, and the dye in our yellow fabric, reflect these waves, all the other colored substances absorbing this light. As the red, the green, the blue, and the violet objects received no light waves which they could reflect, but only yellow light waves, which they "tune in" and absorb, these objects could not show color. So we are forced to the conclusion that color is *light,* and that the property by virtue of which a substance exhibits a specific color can be made manifest only when light waves of that color are made to impinge upon it. In other words, it is all a matter of selective absorption—and reflection—of certain wave-lengths of radiant energy.

Structural Colors.

This applies, however, only when the color seems to be inherent in the substance, as in case of pigments and dyes. It does not apply to such color phenomena in nature as the rainbow, nor does it apply to the colors of a soap bubble, or of a film of oil on a wet pavement, which are phantom colors, usually spoken of as structural colors. In case of the rainbow there is no selective absorption of certain wave lengths, but merely a dispersion of light, due to the fact that the droplets of water, acting like prisms, refract the light that is transmitted, alter the direction of the light waves, and this to a degree dependent upon their lengths, thus causing the constituent colors of white light to spread out fan-like, so that those of longest wave length, namely, the red, are at one extreme, and the violet, which are the shortest, at the other, for the shorter the waves the greater is their refraction by the prism. This display of colors is technically called a solar spectrum. Spectral hues are exhibited by the diamond, by prisms of glass, and by certain liquids like carbon disulphide, when these are traversed by white light.

The colors exhibited by the soap bubble, by a film of oil on water, by fish scales, by opals, by certain laminar rock, like mica, by the wings of the dragon fly and other insects, by certain bird feathers, are largely the results of interference of light waves, though in some cases, as in opals, pearls, insect wings, etc., diffraction plays a part also. The phenomenon of interference is produced only when

white light plays upon an exceedingly thin layer or film of a transparent refracting substances, and the play of colors is due to the interference of light waves reflected from the top surface of such a medium, and the light waves reflected from a layer of air, or other material, with which the medium is in contact. The analogy of waves in water will help us to understand this. When water-waves, moving in different directions, intersect, we find that if their troughs and their crests coincide, the disturbance is augmented at the point of intersection. If, however, crest meets trough, the one wave compensates for the other and the disturbance is minimized or annihilated. And in like manner, the light-waves emanating from points above and from points below a film of oil, for example, may interfere and when a color wave is thus annihilated, the complementary color is observed.

A film or layer to produce color effects by interference must be exceedingly thin, thinner than the length of light waves; that is to say, must be from 1/50,000 to 1/100,000 of an inch, or thereabouts, in thickness. As such a film or layer is usually not of uniform thickness, and as the refraction index of course remains the same, it will show a certain color at one point, and a different color where the film is thinner or thicker. Thus we get the effect of rainbow colors. In case of carborundum crystals the play of colors is very gorgeous, and is said to be due to the fact that these crystals are covered with a thin layer of silica, which serves as the transparent, refracting medium. Some bituminous coal, popularly known as peacock coal, shows interference colors. So do polished surfaces of silver or copper when they have been exposed in an atmosphere containing hydrogen sulphide, in which case a thin layer of the sulphide of these metals acts as the refracting medium. A similar effect is produced by burnished iron or steel, which has been heated in a flame. Here the explanation lies in the fact that a thin layer of oxide is produced. A new spatula, held in the Bunsen flame, or a new copper water bath, which has been allowed to "go dry" over a flame, shows this effect beautifully. Mica gives the color effects of interference, due to the fact that this substance has a laminar, that is, a layer, structure, with light reflected from the upper and the lower surface of the top layers.

Scattered Light.

A cumulus cloud, floating in the northern sky on a bright afternoon, reflects all the wave-lengths of the visible light, and appears like a great ball of white cotton. Unsized white paper, like filter paper, reflects light in a similar manner, namely, with diffusion. This is due to the fact that the surface is made up of countless inequalities, so that the light is caught at many angles, and is reflected in corresponding directions. Glass, the surface of which has been ground, exhibits no lustre, but reflects scattered light. If, however, the light is reflected from a smooth surface, with the particles of the homogeneous material closely packed, and the inequalities not exceeding about a quarter of a wave length of the light waves, the reflected light is not diffused, and we observe what is known as lustre. If the object is of a substance of very low penetrability, and with a refractive index within a certain range, the lustre may be of the kind spoken of as metallic, because most metals, when polished, reflect light in this manner. But metallic lustre is not limited to metals, and is observed in the crystals of a number of organic dyes, is possessed by lumps of indigo, of Prussian blue, and with modifications, by the hard wings of certain beetles, and by some bird feathers. A wavy surface seems to augment this effect, and the surface of water, gently rippled, when viewed by moonlight, appears to have metallic lustre. So does a test tube filled with air, when viewed under water, look as if it were full of mercury. In case of certain metals white light is reflected with little or no selective absorption. Gold and copper are, however, capable of absorbing selectively the shorter wave-lengths with reflection of the red end of the spectrum, diluted, of course, with a considerable amount of white light.

Color Modified by Powdering.

If now we examine a crystal of potassium dichromate, we note that while it reflects light, it also transmits it, and that it is fairly transparent. We also observe its orange-red color, due to selective absorption, the unabsorbed light waves being reflected or transmitted. If we powder the crystal, its color will appear less pronounced. The impinging light will now not penetrate so deeply, and our powder is in fact opaque, for the spaces between the particles are filled with

air, and the index of refraction of the potassium dichromate grains is different than the refractive index of air. So it is opaque for the same reason that a mass of ice crystals is opaque or a snowball is opaque. The reflected light will be diffused or scattered, as the crystal particles will present countless surfaces, facing in many directions. Every colored substance which is transparent or translucent, will appear lighter in color after it has been powdered. If, however, the substance is exceedingly opaque, and of a character to diffuse or scatter the reflected light, no appreciable difference in color will be noticed after powdering. Thus, the crystalline red mercuric oxide becomes yellow when reduced to a fine powder, while lumps of yellow oxide of mercury show no appreciable change in color when subjected to subdivision. Red oxide of iron is another conspicuous example of a substance which varies in color with the degree of subdivision, varies from yellow for very fine particles to deep red for larger ones.

Another reason why a pigment in large grains appears richer in color than the same pigment in fine powder is found in the fact that the large grains pack loosely, and we see the effect of multiple reflection, as light enters between the grains and the unabsorbed waves are reflected back and forth, repeatedly, and the color is thus purified. For the same reason the inner surface of a golden cup will appear much redder than the surface on the outside; and velvet will appear richer in color than will silk dyed with the same dye substance—a matter of multiple reflection.

Selective Scattering.

All cases hitherto considered involve color-effects due to selective absorption, or to dispersion, or to interference of waves from the upper and the lower surface of a film. But none of these explanations fit such phenomena as the sunset colors of the sky, nor do they help us to understand why the clear sky when the sun is near the zenith, is ordinarily blue. It appears that particles, by virtue of their dimensions, rather than by their inherent nature, scatter light selectively. Thus the minute particles in the atmosphere, scatter blue light. A similar effect can be produced in water by dropping into it a few drops of an alcoholic solution of mastic, which is really an amber-colored substance. Zinc oxide, in exceedingly fine subdivision, is bluish. Glass which has an opaque white powder dif-

fused through it, always shows, if it is not too opaque, a distinct bluish tinge. So does skimmed milk.

Professor Bancroft has obtained the same result of scattered blue light by heating hard glass tubing until it began to devitrify. It has been demonstrated also that the blue color of the feathers of the blue jay, of the blue bird, and of other blue bird feathers is due to the scattering effect upon light by the minute air bubbles in the transparent substance constituting these feathers. Similarly, the color of colloidal gold, both in aqueous media or in glass, is either red, purple or blue, according to the size of the particles. The smoke from the burning end of a cigar is quite blue, while the smoke blown from the mouth of the smoker is white—probably because, on account of its high moisture content, it is made up of larger particles which reflect all the wave-lengths. When the sun is near the horizon, and shines through denser layers of atmosphere, laden with smoke, dust particles and water droplets, we observe selective transmission, as in the case of a colloidal solution; and of course, selective scattering plays a part. As the yellow merges with the sky-blue, there results a greenish tint; and red and blue give us purple, which diluted with the white light reflected from fluffy clouds produces the lilac and amethystine hues. Dense clouds before the sun are opaque, and show black; if they are less dense, permitting white light to filter through, they appear gray; and the gray, with red and yellow, in various proportions, adds to the variety of tints and shades of the evening sky.

Dichroism and Fluorescence.

Turning now from the color phenomena of the sky to the prosaic solids and liquids in our laboratory, we may with profit briefly consider yet another interesting fact connected with selective reflection and transmission of light waves. We find that most transparent liquids and solids possessing color, as for example, copper sulphate solution, or copper sulphate crystals, exhibit the same color by reflection as they do by transmission. Moreover, a weak solution of copper sulphate has the same color as a strong solution, a thin fragment of crystal is blue just as a large crystal is blue. The only difference is the depth of color—a matter we can readily understand.

But a weak solution of methyl violet is bluish, while its concentrated solution looks red. Indigo carmine solution has this same characteristic. It is indeed a property of a rather large number of dyes, and of other substances, and is known as dichroism—from the Greek prefix di—meaning two, and the Greek word for color, namely chroma. The explanation of dichroism is found in the fact that these substances show a difference of permeability to the different wave-lengths which are not absorbed. When this difference is very pronounced, the reflected color is different from, and usually complementary to, the color which is transmitted. A number of dyes are decidedly dichroic. Erythrosine offers an illustration.

Dichroism should not be confused with fluorescence, which involves also the transformation of short wave-lengths of radiant energy into longer waves, and which may be instrumental in rendering visible, wave-lengths which are too short for human vision, namely, the ultra-violet rays. Fluorescence was first observed in fluor-spar, hence the name. Solutions of fluorescein, uranin, aesculin from the bark of the buckeye tree, quinine sulphate, are fluorescent. The greenish "bloom" of lubricating oils from petroleum is due to fluorescence. Calcium tungstate is fluorescent and is used largely in connection with X-ray work, being the basis of the fluorescent "screen."

Phosphorescence.

Phosphorescence, it should be remembered, is distinguished from fluorescence in that it involves the emission of light "in the dark." A substance possessing this property, will when exposed to radiant energy, become luminous, and will continue to glow after the exciting light has ceased to impinge upon it. True phosphorescence does not involve the chemical alteration of the substance; at least not in the sense in which this is the case when phosphorus glows, this being a matter of oxidation. Nor is the term itself, phosphorescence, referable to phosphorus, but was derived from Bolognese phosphorus, a common name for impure barium sulphide, which is characterized by this property of glowing in the dark. Other common phosphorescent substances are the impure sulphides of calcium, and of zinc; and these three sulphides are common ingredients in "luminous paints." A very large number of substances are fluorescent or phosphorescent to a slighter degree. The difference between these sulphides and the compounds of radium, with

reference to luminosity, is simply this: radium in its disintegration produces its own radiant energy, while phosphorescent substances must be activated, or "charged," with light from another source.

Color Screens.

Most common substances are presumed to reflect light only while this is being received—as does the moon. Nor are there many substances which alter wave-lengths of the visible spectrum. Hence a pigment or a dye, that is, a substance capable of selective absorption and of selective reflection, can exhibit its characteristic color only when viewed in light which embodies the wave-lengths which the substance reflects. And in this connection it should be remembered that gas light, incandescent light, in fact, artificial light generally, is somewhat different in composition from sunlight, being richer in the yellow waves. A colored substance will therefore appear different under such light. When tinted electric light bulbs, or tinted shades are employed, these do not add something to the light, but subtract from it. They operate as filters, absorbing certain wave-lengths, and transmitting the remainder. Thus a red bulb does not add red but transmits the red rays of white light, absorbing the rays of shorter wave-lengths. If the red glass is designed to serve as a perfect filter, only substances reflecting red will show color, and all other colors will appear black. But since most pigments reflect other colors besides their dominant hues, the use of colored globes and shades not only lowers the illumination, but may produce rather bizarre effects on our wall paper, and on the furnishings of our dwellings.

Color-blindness.

But as to that, let us remember that we do not all see alike anyway, when it comes to color perception. Some folks, in fact, are color-blind, which seldom means that they cannot see color at all, but means that they cannot see all the colors. The commonest type of color-blindness is red-blindness while occasionally green-blind persons are encountered. The great John Dalton, who formulated our modern atomic theory, was red-blind, and was the first to scientifically describe this affliction, which, even to this day, is occasionally referred to as Daltonism. A red-blind person lacks range in "tuning in" the waves of the spectrum, and the longer waves which give to normal eyes the sensation of red, are not perceived. Naturally, other colors

are correspondingly modified. To a color-blind person the hues of sky and fields, of our familiar flowers, our dyes and paints and pigments, bring color-sensations quite different from those which are conveyed to you or me. So we come again to our initial statement: color may be thought of subjectively, as a sensation which we receive through the eye. Regardless of all that science can teach us about color, it's something we see; and as to this phase of it, there is much which we cannot as yet see to understand. We do not know why a certain wave-length should make us "see red"—it's a mystery.

The Unsolved Riddle.

In the objective study of color we have a great accumulation of facts—about wave-lengths, reflection, refraction, diffraction, dispersion, interference, scattering, selective absorption; about pigments and dyes, and their chemical make-up; about chromophores, and how to synthesize compounds which possess color. Science has also gone beyond the demonstrable facts into the realm of speculation, and has tried to evolve a hypothesis connecting the phenomenon of selective absorption with the electron theory. But here we might remember that a hypothesis is "a theory on probation," and that speculative thought in science means reasoning from premises not yet proven.

——, a professor and his young son, passing along Main Street, encountered an elderly person with a big red nose. "Homo sapiens proboscis rubiflora," said the professor to himself in an undertone, for he had the habit of cataloguing all strange specimens which came to his notice. But the little boy cared nothing about biologic nomenclature, and less about Latin. His was the curiosity of the true scientist. "Why," asked he, "why is that man's nose so red?"

Why, indeed? Much could be said on that subject. It could be dealt with from the standpoint of physics, or of chemistry. It is a problem in pathology. And as a theme for the moralist or the humorist a red nose is inexhaustible.

But when it came to the fundamental question, "why," our professor deemed it wise to say to his son—very simply—"Color, my son, is one of the great mysteries, and a mystery is something about which we know only enough to make us curious."

And this, indeed, is what science is still compelled to say about color. We know just enough to make us acutely curious.

THE MINERAL AND VEGETABLE RESOURCES OF THE SEA

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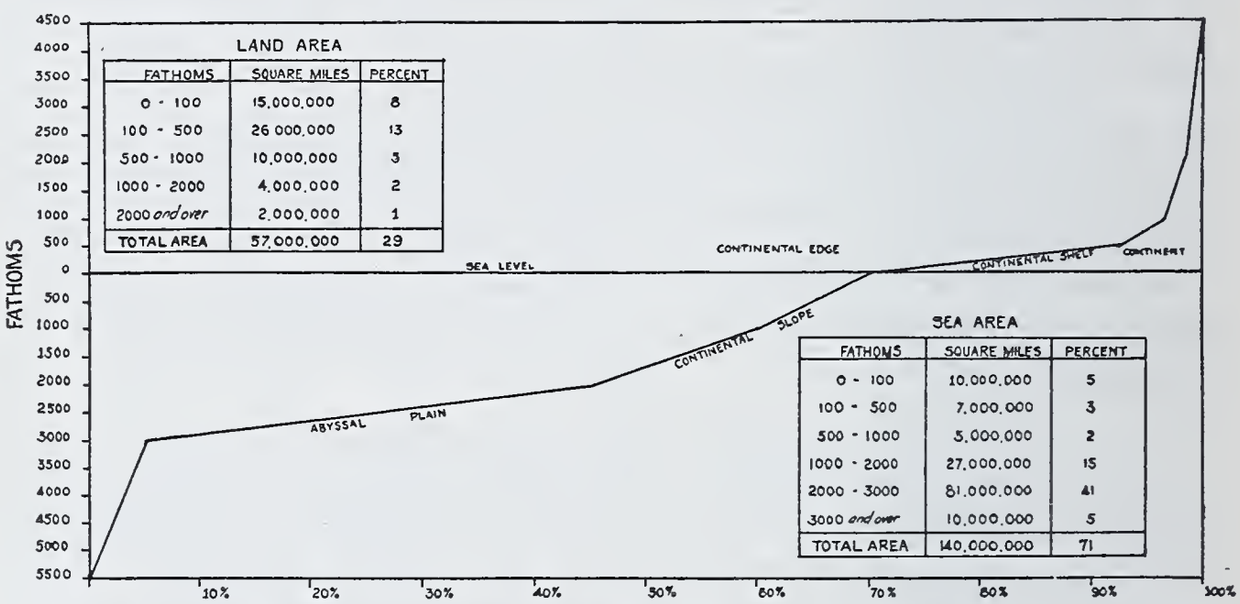
TO THE landlubber, thoughts of the sea come only at vacation time, or when taking an ocean voyage. We know that the sea is salt, and that certain sea foods are very tasty. But there is much more of interest to be known.

The sea is so vast that it is difficult to appreciate its extent and volume. It covers nearly three-fourths of the earth's surface, about 139,000,000 square miles and is approximately 302,000,000 cubic miles in volume. The diagram will give some idea of the relative land



LAND AREA

FATHOMS	SQUARE MILES	PERCENT
0 - 100	15,000,000	8
100 - 500	26 000,000	13
500 - 1000	10,000,000	3
1000 - 2000	4,000,000	2
2000 *and over*	2,000,000	1
TOTAL AREA	57,000,000	29

SEA AREA

FATHOMS	SQUARE MILES	PERCENT
0 - 100	10,000,000	5
100 - 500	7,000,000	3
500 - 1000	5,000,000	2
1000 - 2000	27,000,000	15
2000 - 3000	81,000,000	41
3000 *and over*	10,000,000	5
TOTAL AREA	140,000,000	71

DIAGRAMMATIC SECTION SHOWING THE AVERAGE CONTOUR OF THE EARTH.
BASED UPON THE PERCENTAGES OF THE AREAS BETWEEN THE CONTOUR LINES ABOVE AND BELOW SEA LEVEL

and sea areas and also of the various depths of the ocean as compared with the elevations on land. It has been calculated that the mean average depth of the ocean is 12,060 feet, while the mean elevation of the surface of the continents above sea-level only 2300 fet. Nevertheless, the greatest depths of the ocean below sea-level and the greatest heights of the land above it are about the same, the summit of Mt. Everest rising to 29,000 feet above sea-level, while the Mindanao Deep, recently sounded near the Philippine Islands, sinks to 33,000 feet below sea-level. In general, the contour of the ocean bed resembles that of the land, with formations corresponding to our hills and valleys, plains, slopes and plateaus.

The deposits of the ocean floor may be classified into (1) deep sea deposits (beyond 100 fathoms), (2) shallow water deposits (less than 100 fathoms), and (3) littoral deposits (between high and low water marks). The deep sea deposits are those formed in deep water remote from land, and, depending on the depth, may be of the nature of clay, mud or ooze. The shallow water and littoral deposits are of sand, gravel and mud, and result from the continuous erosion of the coast by wave action.

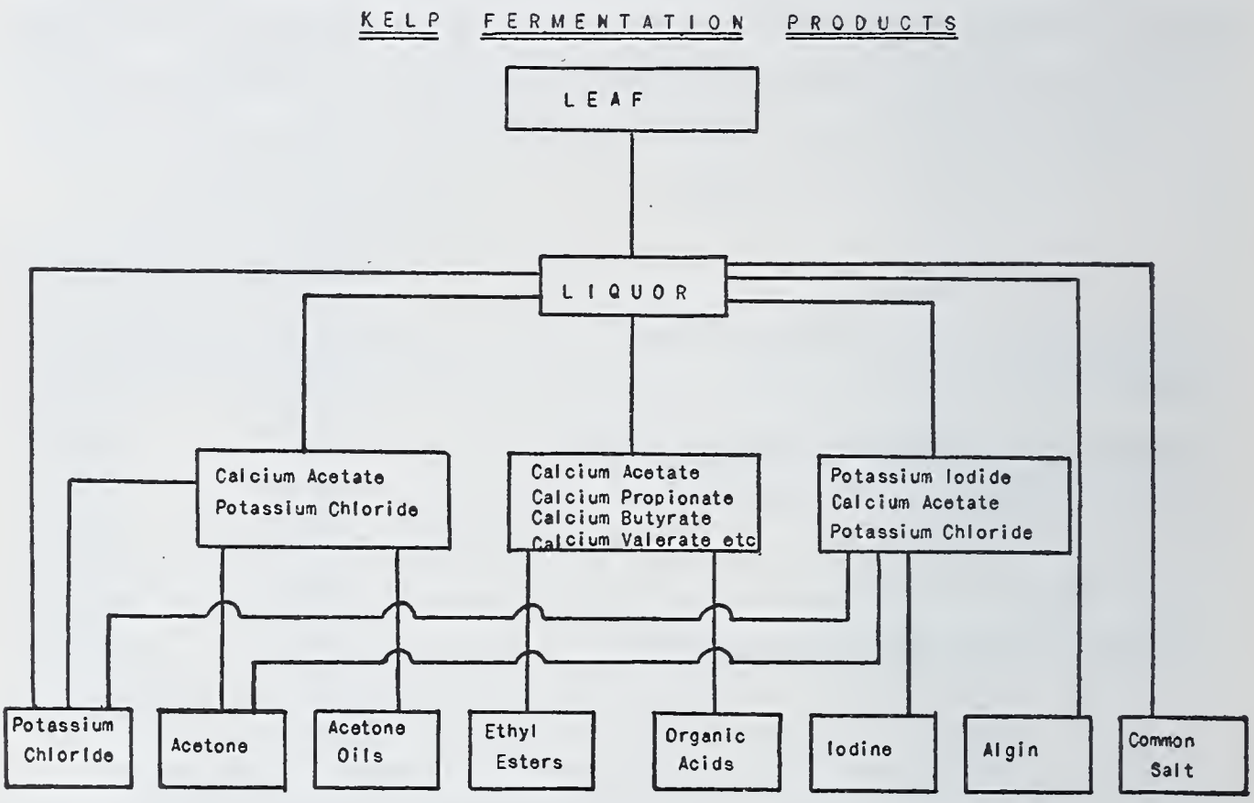
We say that the sea is salt, but the saltiness is not due to ordinary sodium chloride alone. If we evaporate sea water to dryness, the resulting solid will contain not only sodium chloride, but also magnesium, calcium and potassium in the form of chlorides and sulphates. There are present also appreciable amounts of bromine, iodine, iron, silicon, carbonate and phosphate. The figures given in the following table may be said to approximate the average composition of sea water and sea salt.

	Per 1000 Parts of Water.	*Per Cent. of Total Salts.*
Sodium Chloride (Common Salt)	27.213	77.758
Magnesium Chloride	3.807	10.878
Magnesium Sulphate (Epsom Salt)	1.658	4.737
Calcium Sulphate (Gypsum)	1.260	3.600
Potassium Sulphate	0.863	2.465
Magnesium Bromide	0.076	0.217
Calcium Carbonate and Residue	0.123	0.345
	35.000	100.000

Thirty-three of the eighty known elements have been identified in sea water and included among these are gold, silver and radium. The amounts of these elements are very small, but this has not deterred some unscrupulous persons from trying to sell stock in companies organized to extract "gold from sea water." It has been estimated that a cubic mile of sea water contains gold to the value of $93,000,000, but the cost of recovering this gold is hundreds of times greater than the value of the gold obtained.

Although we look upon ordinary salt as common and cheap, it is a very necessary commodity. Not only do we need it in seasoning and preserving food, but in the curing of hides, the making of brines for refrigeration and ice factories, in the making of dyes and for the

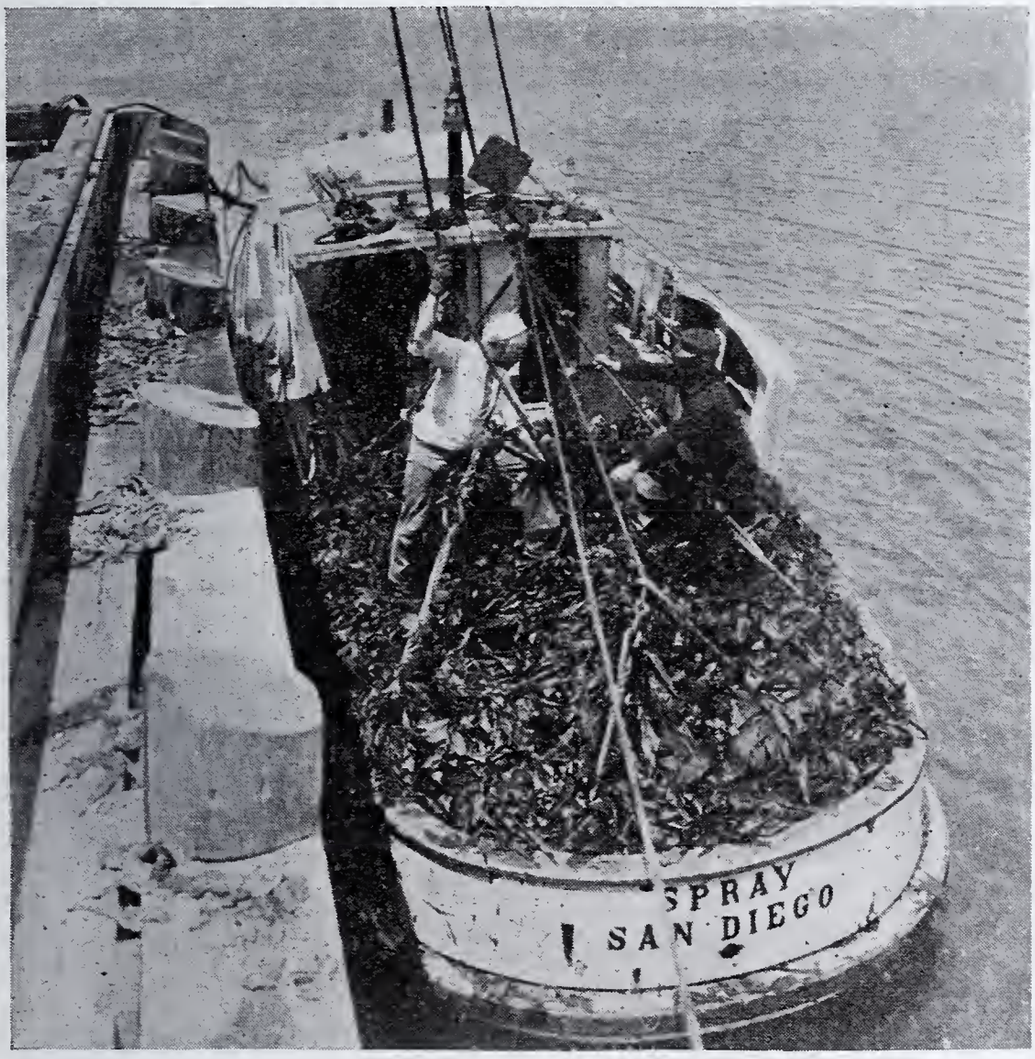
preparation of sodium and chlorine. Large quantities of salt are used in oil refining, the ceramic industries, in metallurgy, paper works and the textile industry. While it is true that most of the salt produced in this country is obtained from crude rock salt or from natural brines, the manufacture of salt from sea water by solar evaporation is still an important industry in many warm countries where the rainfall is light. In California more than 97 per cent. of the salt produced, is made from sea water, evaporated by the heat of the sun, and in Italy, Portugal, France, China, Japan, India, Brazil and many of the islands of the West Indies, the solar sea salt industry is of importance.



In the refining of sea salt, many by-products may be recovered. Included among these are magnesium sulphate, magnesium chloride, potassium chloride, bath salts, low-grade salts, magnesium oxychloride cements and artificial stone. Metallic magnesium and bromine have also been prepared on an experimental scale.

The salt that we use as a condiment is very pure sodium chloride, but of late there has been some suggestion toward the use of unrefined sea salt. As this contains, other than sodium chloride, traces of the thirty-odd elements said to be present in sea water, it will furnish a salt containing all of the elements necessary to proper growth and health. It will contain iodine for the thyroid

gland and fluorine for the bones and teeth. Goiter, caused by iodine deficiency, will be prevented by the use of a salt containing the required iodine. As a matter of fact, there has recently appeared on the market an "iodized salt," containing one part of potassium iodide to 5000 parts of the salt. The next logical step will be the marketing of unrefined sea salt for use in place of the highly refined table salt



Courtesy Hercules Powder Company.

UNLOADING KELP FROM LAUNCH.

now available. To overcome the tendency of sea salt to take up moisture and cake, a recent investigator has found that if six grams of phosphoric acid per liter is added to sea water, and the mixture evaporated to complete dryness, the resulting mass will be non-hygroscopic and of pleasant taste. It will contain all of the mineral salts required by the human body. Its general acceptance and use will be another step in the "back-to-nature" movement in foods, which has received so much publicity of late in connection with the study of vitamines.

The sea is teeming with animal and vegetable life. The largest animals and the largest plants are found in the ocean. It has been estimated that the vegetable matter of the seas is equal in amount to the plant growth of the land, and very little of this is utilized at all. Some seaweed is used as fertilizer along the coast in the British Isles, Europe, Japan and elsewhere and about one-third of the world's supply of iodine is obtained by burning seaweed or kelp. In some places where forage crops are scarce and dear, seaweeds are occasionally fed to stock. In countries such as Japan and Hawaii, where vegetables are relatively high in price, seaweeds form a regular part of the diet of certain classes of the people.

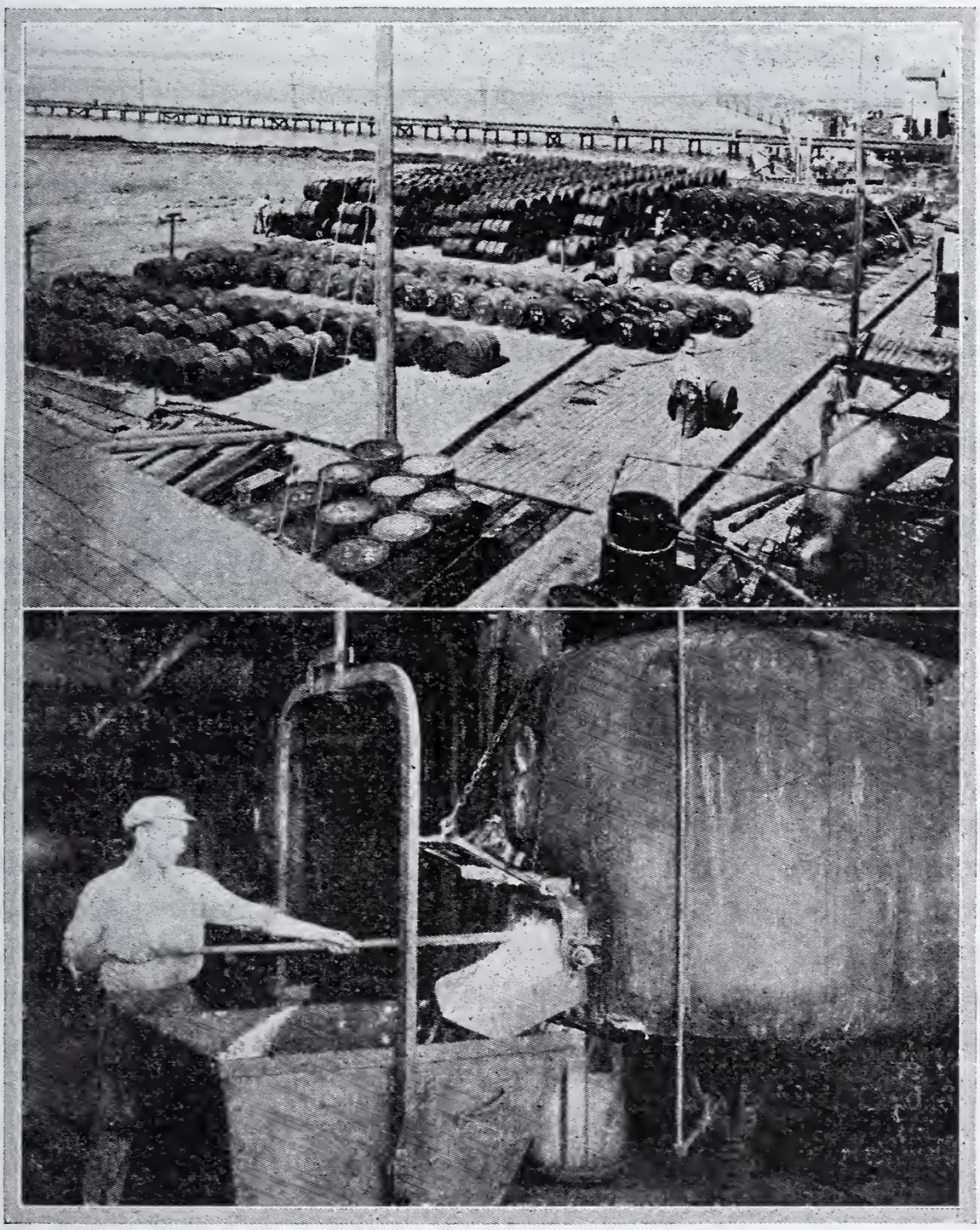
Many suggestions have been made for the more varied and extensive use of seaweeds or marine algæ. Over five thousand species have been noted, ranging in size from microscopic to very large. They are simple plants and ordinarily grow either under or partly under water, and either attached to the bottom or floating. There is no true differentiation into root, stem and leaf and they reproduce by spores. Being chlorophyllous plants they are able to synthesize carbohydrates from carbon dioxide and water, by means of the energy received from the sun's rays.

As stated before, some of our iodine is obtained from the ashes of seaweeds. But these ashes were utilized long before iodine was discovered, being used as a source of alkali needed in the manufacture of glass, soap and alum. The composition of the ash varies for different species, but contains principally potassium and sodium carbonates, chlorides, iodides and sulphates of potassium and sodium, calcium carbonate and siliceous matter.

In the United States, seaweeds were not utilized until about 1900, when the high potash content of the Pacific coast seaweeds or giant kelp was recognized. Kelp beds extend all along our Pacific coast, from San Diego to Alaska, insuring ample supplies of raw material. The outbreak of the World War and the scarcity of potash, gave impetus to the exploitation of these kelp beds as a source of potash, and in 1917 the United States Department of Agriculture, by authority of Congress, erected an experimental kelp potash plant at Summerland, California.

In the process used at this experimental plant, the chopped kelp is first dried, and then distilled in a specially designed retort. The volatile products are drawn off at the top of the retorts and the kelp

fed in at the top gradually works downward as it shrinks in volume. After passing the hottest part of the retort, the char is discharged into a small hopper, constituting the bottom of the retort, where it



Courtesy Hercules Powder Company.

(Upper) **ACETONE IN DRUMS READY FOR SHIPMENT.**
(Lower) **REMOVING POTASH FROM DRYER.**

partially cools. At regular intervals this is removed, cooled and ground.

The volatile products are condensed, yielding an oily liquid and an ammonia liquor. In addition, some gas is returned and burned under the retorts. The oils and ammonia obtained are valuable by-products.

Potash is extracted from the charred kelp by a leaching process, leaving behind a charcoal known as "kelpchar," which has excellent decolorizing properties. The mother-liquor obtained in the crystallization of the potash, is worked for iodine.

Reference to the chart will show the detailed operations and end products of this destructive distillation process.

During the war this kelp potash industry was second in importance in the United States. At the end of the war and upon the resumption of shipments of foreign potash the plant was dismantled, as competition with the cheaper supply from abroad could not be met.

Another interesting utilization is illustrated in the Hercules Powder Company's method for producing acetone by the fermentation of kelp. Large quantities of acetone are required in the manufacture of smokeless powder and, during the war, it became necessary to devise a new method for making it.

In this process the chopped and macerated kelp is placed in large wooden tanks, diluted with water, and allowed to ferment. Each tank is equipped with hot water coils to regulate the temperature and with compressed air pipes for agitation. The proper acidity of the fermenting "mash" is maintained by adding calcium carbonate from time to time. In the fermentation, which requires about two weeks, various organic acids are formed, such as acetic, propionic, butyric, valeric, etc., which in the presence of calcium carbonate form the corresponding calcium salts.

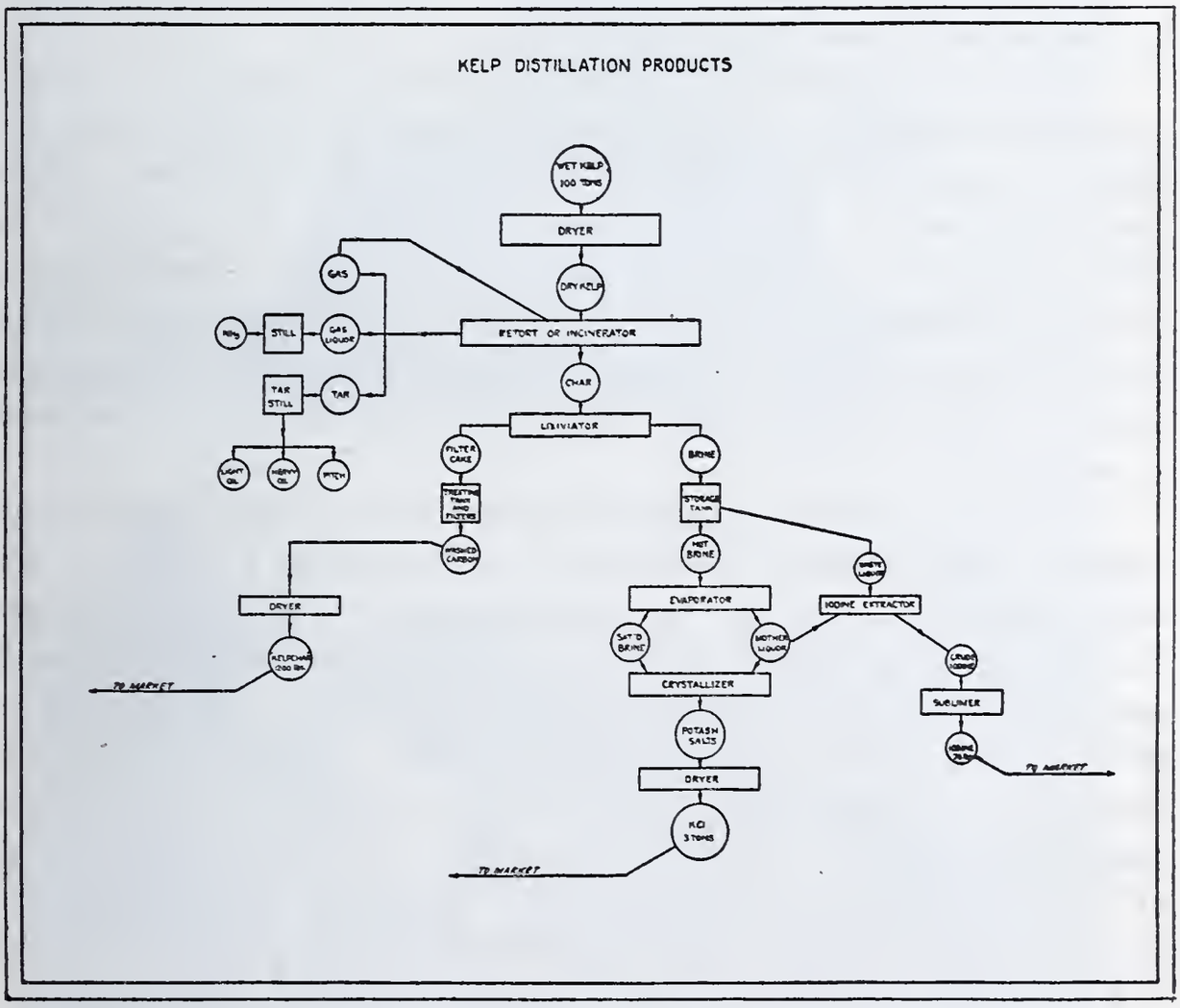
After fermentation, the liquor is screened, allowed to settle and then filtered. The screened material is used in the preparation of algin, which will be referred to later. The filtrate upon concentration and evaporation yields first a scum or "taffy" consisting of a mixture of calcium acetate, propionate and valerate and is used in the making of solvent esters, by mixing with ethyl alcohol and sulphuric acid, the esters formed being separated by fractionation.

Upon further concentration, crude calcium acetate, containing some potassium chloride, separates. This mixture upon heating in retorts yields acetone and other mixed ketones, the residue of calcium

carbonate and potassium chloride in the retort being leached for the potash.

The final product of the concentration is potassium chloride, 95 to 98 per cent. pure. Iodine also is recovered. The chart shows the ultimate products obtained in this fermentation process.

This plant, also, was dismantled immediately following the war, as the process was evidently not profitable under peace time conditions. Although designed and operated primarily for the manufacture of acetone, the by-products were all valuable and useful.



It is believed that it is possible to produce potash from kelp at a profit, provided all of the by-products are utilized and provided that the kelp can be harvested cheaply enough.

In this country, very little seaweed is eaten, although Irish moss and dulse are used in some sections, by certain classes of people. In Japan and Hawaii, however, seaweeds are of such importance as to necessitate their artificial cultivation. The Japanese children are early taught to eat seaweed foods and are told that they are "brain

foods," much as the young children in this country are taught to eat the crust of bread "to make the hair curly." The use of seaweeds, containing natural sea salt, in the diet of the young Japanese may account for the wonderful teeth for which the Japanese are noted.

Chief among the seaweed foods eaten by the Japanese are *amanori* and *kombu*. *Amanori* is prepared by baking the particular seaweed over a fire until it is crisp. This is then eaten with soups or broths, or made into *sushi,* which corresponds to our sandwich. Boiled rice is piled upon a sheet of the baked *amanori,* and then strips of meat or fish are placed on the rice. The whole of this is rolled up and cut into transverse slices.

Kombu is prepared for eating in a variety of ways. Most important is shredded green dyed *kombu,* prepared by dyeing the dried kelp in a large kettle containing a solution of malachite green. After dyeing, the kelp is partially dried, then flattened out, arranged in piles, compressed and then shredded with a plane. The finished product resembles in color, shape and feel, the Spanish moss which hangs from the trees in our southern states. It is one of the standard foods of Japan and is cooked with meats and soups and also used as a vegetable.

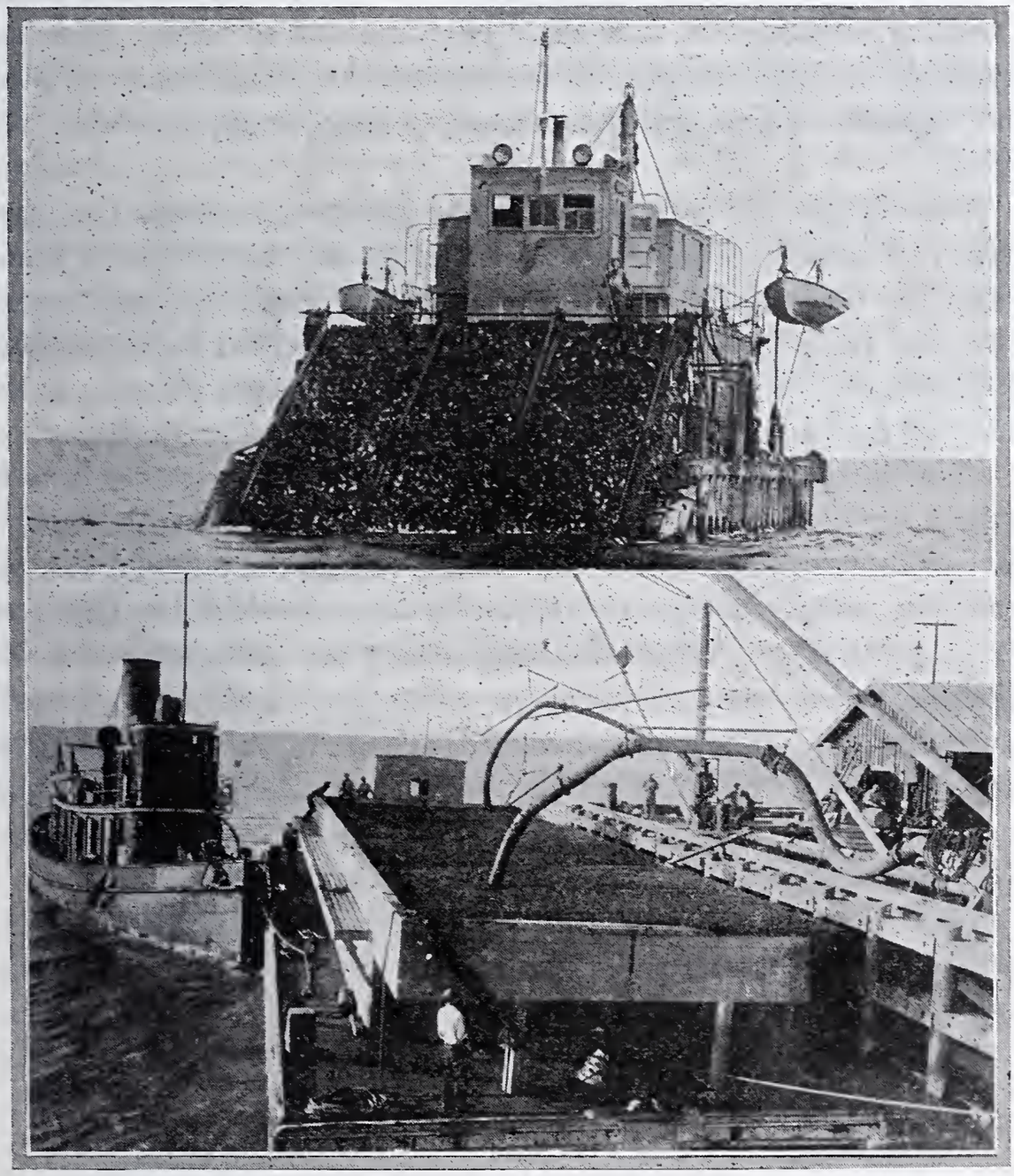
Agar-agar is also a favorite seaweed food of the Japanese and Chinese, being eaten in the form of jellies and as a thickener for soups, sauces and gravies. In the preparation of agar-agar, the selected seaweed is cleaned, bleached and then boiled with water until practically all of the seaweed has gone into solution. The solution is then strained and the strained extract allowed to cool, when it solidifies into a firm jelly. The jelly is cut into strips and frozen. This causes the water to crystallize out, so that when later thawed, most of the water runs out, taking with it the substances which are soluble in cold water. The agar-agar is then dried, cut into uniform lengths and packed in bundles.

In the United States, the manufacture of agar has been one of the few novel industries that have been introduced since the World War. The process used is essentially the same as the Japanese process.

Agar is a substance having many valuable properties. The chief constituent is a carbohydrate, pectin-like substance called d-galactan or gelose. It swells rapidly in cold or lukewarm water and if boiled until solution is affected, it will form a stiff gel when

cooled to room temperature. Even a one-half per cent. solution will give a firm jelly.

In this country, agar is used chiefly in medicine and in bacteriological work, but as it becomes better known and cheaper, it is sure to find increasing use in the culinary arts.



Courtesy Hercules Powder Company.

(Upper) **TYPE OF HARVESTER USED IN GATHERING KELP.**
(Lower) **REMOVING CHOPPED AND MACERATED KELP FROM BARGE.**

Algin, or alginic acid, previously referred to as a by-product in the fermentation process for kelp, occurs in large quantities in many seaweeds. From this algin can be made salts known as alginates,

of which sodium alginate is the most useful. It may be used as a sizing material, for fixing mordants and for many other purposes. Materials which have been treated with sodium alginate may be made waterproof by treatment with weak hydrochloric acid and washing. Recently, a series of products known as "Alkagels" have been put on the market for use in alkali- and water-proofing cements and stucco, as binding material, for insulating purposes and so forth. The basic ingredient in these compounds is presumed to be ammoniated aluminum alginate, which has the property of becoming insoluble after drying.

Among the odd uses for seaweeds may be mentioned the manufacture of paper, cloth, ornaments and curios, and even in Kamschatka for the preparation of an alcoholic drink. The word "hooch" is derived from "hoochena," the name of a distilled liquor made by the Eskimos. In this distillation the Eskimo makes use of the long hollow stems of certain kelps, coiled in the form of a condenser.

The intensive cultivation of the more valuable seaweeds is not entirely impossible, and as the ocean is transparent to a depth of nearly a thousand feet under normal conditions, the sunlight can penetrate and supply energy to vegetation at a considerable depth and over a great area. When this time comes we will then have what might be called "marine farming," or "cubical cultivation," as Dr. Slosson calls it. Thus, the unwary purchaser of a submerged ocean front lot may, after all, turn his loss into a profit, by planting and harvesting large crops of succulent seaweeds or high potash kelp.

CHEMISTRY IN AND ABOUT THE HOME

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THE AVERAGE individual does not realize how very intimately our everyday activities are tied up with chemical phenomena, that probably the action of every organ of our bodies is accompanied by some one or more chemical changes, that, whether in motion or at rest, asleep or awake, every one of us is in a very true sense a chemical laboratory or factory. The detailing of the processes carried out constantly, or occasionally, as the case may be, would be a long story, though an exceedingly interesting one. Perhaps we shall try some day to tell it, but we have another story to tell tonight which comes very close to most of us, a story which shows us that the home, too, is in a very real sense a chemical laboratory.

While it is true that the study of some phases of chemical science offers difficulties that the keenest of minds have not yet been able to surmount, there are many others of so simple a character that the layman of average intelligence and no special training can easily understand them, yet which often exercise a profound influence in determining our happiness or unhappiness, according as we do or do not take cognizance of them.

It is almost, if not quite, impossible to consider chemical phenomena without noting those of a physical character. There does not seem to be the sharp dividing line between chemistry and physics as many of us may once have imagined as existing. Chemical changes are perhaps always accompanied by physical changes (not always easily noticeable, however), though the reverse is not always, or even generally true.

About a year ago the speaker started out, in a lecture given in this room, to demonstrate chemistry in the home, but, though he talked rather rapidly for considerably more than an hour, he got no farther into the subject than, figuratively, to get the fires in the heater and kitchen stove going in good shape, and the house com-

fortably heated, without waste of fuel and without danger to the household. When he began this year to get together data for another lecture on the subject he soon realized that there is still more to be said than can be covered properly in an hour or so, and the question that first demanded an answer was: How can this subject be presented in order to bring out a lot of valuable information for his hearers in a rather limited amount of time, and yet in an interesting manner? What follows is his solution of the problem.

The speaker asks you to accompany him as he follows the footsteps of Mrs. Average Housekeeper as she goes about the performance of her duties in her home on a Monday morning of any week in winter. It is to be hoped that you got well rested over Sunday, for we are destined to do "some walking" if we take a step for every step she takes this day. It is too bad that someone has not a pedometer on his foot to record the distance we shall travel.

In the language of Scripture, "She riseth while it is yet night and giveth meat to her household," but before she can serve that meat she has to initiate and carry out a number of chemical reactions. Her house not being an "electric home," she first strikes a match and at once initiates a group of reactions. Let us see what some of them are.

If the match she uses is a so-called "strike anywhere" match, its head is composed of an intimate mixture of (a) a cementing material (probably glue), (b) an oxidizing agent (potassium nitrate, potassium chlorate, brown oxide of lead, or some other chemical which easily parts with part or all of its combined oxygen), (c) a combustible material (phosphorus sulphide, sulphur, antimony sulphide, or some other chemical which easily takes up oxygen), (d) a gritty material (fine emery, pumice, powdered glass, or some other substance which helps to produce friction when the match is rubbed on even a comparatively smooth surface).

If the match is a so-called "safety" match, the composition of the head is somewhat different, the chief difference being that it holds no phosphorus or compound of phosphorus, the phosphorus (the red variety, a non-poisonous substance) being a constituent of the special rubbing surface on the box or other container.

In making the matches the materials constituting the head are mixed and made into a paste with water and the sticks dipped into this to the proper depth, withdrawn and allowed to dry. The body of the

match may be of wood or paper, and the end which is to carry the head is usually first dipped into melted paraffin, stearic acid or some other easily inflamed substance. The paraffin is a mixture of hydrocarbons (compounds of hydrogen and carbon), the stearic acid, paper and wood are all compounds of carbon, hydrogen and oxygen.

The friction produced in the striking of the match develops heat enough to start chemical action among the several constituents of the head, as follows:

The oxidizing agent gives up oxygen in the atomic form (nascent oxygen) which is very active and combines with

(a) Phosphorus to form white fumes of phosphorus oxide (P_2O_3 or P_2O_5).

(b) Sulphur to produce a bluish flame and form a colorless gas of suffocating odor, sulphur dioxide (SO_2).

(c) Hydrogen to produce a colorless flame and form a colorless gas, hydrogen oxide (H_2O), which, by the way, is the gaseous form of our old friend, water.

(d) Carbon to produce a colorless flame and form a colorless gas, carbon dioxide (CO_2), the same gas which gives the "fizz" to our soda water, the lightness to our bread and cakes, and which causes the family lime water bottle to assume so unsightly an appearance, the CO_2 of the air reacting with the slaked lime [$Ca(OH)_2$] to form insoluble calcium carbonate ($CaCO_3$).

(e) Antimony to form white fumes of antimony oxide (Sb_2O_3).

Heat is developed in every one of these reactions.

The heat produced in the reactions taking place in the head vaporizes some of the wax and sets fire to it, and its flame in turn ignites the material of the stick. The carbon and hydrogen in the wax and stick unite with oxygen, the active constituent of the air, to form carbon dioxide and water, respectively. The unconsumed part of the head is a mixture of carbon and new compounds of the metals whose oxygen-liberating compounds were used in making the match head. The black part of the stick is simply unconsumed carbon (charcoal). It is seen that, while a match is, indeed, a small thing, its possibilities as a center of chemical reactions are rather great.

While we have been analyzing the chemistry of the burning match Mrs. Housekeeper has used its flame to ignite the gas of a gas jet, the oil of a kerosene lamp or the wax of a candle. Manufactured gas is generally a mixture of hydrogen (an element), hydrocarbons (compounds of hydrogen and carbon) and carbon monoxide

(CO); kerosene (often erroneously called "coal oil") is a mixture of hydrocarbons; while candle grease may be paraffin (a mixture of hydrocarbons), beeswax, tallow or stearic acid (all of them compounds of carbon, hydrogen and oxygen), or mixtures of several of these. The wicks of the lamp and candle are generally made of cotton or some other natural form of cellulose (one of the carbohydrates, or compounds of carbon, hydrogen and oxygen).

When any of these substances burn it is because the carbon and hydrogen both combine with oxygen from the air, the former to form carbon dioxide (CO_2), the latter to form hydrogen oxide (water, H_2O). In the case of the kerosene, the candle, and the gas (when burned from a flat jet), at least a part of the carbon is momentarily in the elemental state and in very fine particles distributed through the flame, and the luminosity of the flame is due to the temporary incandescence of these particles, because of their being highly heated by the energy liberated by the chemical reactions taking place within the flame. With the mantle type of burner (the so-called Welsbach light) enough air is mixed with the gas to cause the flame to have no illuminating value of its own, but the intense heat of combustion is utilized to make incandescent the rare-earth oxides which make up the mantle. Radioactivity, doubtless, plays some part in making lamps of the mantle type as efficient as they are.

In making a somewhat hasty toilet Mrs. Housekeeper uses a soap, and here again chemistry or physics, or both, come into play. Soaps that are used for cleansing the skin, particularly of the face, need not be expensive, but should be free, or nearly so, of alkali; but even so-called "neutral" soaps produce alkaline solutions with water, especially soft water. Phenolphthalein is the somewhat formidable name of a chemical which is used by chemists as an "indicator" of alkalinity in solutions. In neutral or acid solutions it has no color but in alkaline solutions it has a pronounced pink color, a few drops of a weak solution of it being sufficient to strongly color a quart of solution which is even slightly alkaline in reaction. An alcoholic solution of a neutral soap does not become colored when the above reagent is added to it, but if some of the same solution be now diluted with warm soft water it will assume a pink color. In the language of the chemist some of the soap has undergone hydrolysis (reacted with water) to form a little alkali (sodium hydroxide, NaOH) and a corresponding amount of acid (palmitic, oleic, stearic, etc., depending upon the composition of the fat used in making the

soap). The alkali is more pronounced in its action on indicators than are the acids, hence the pink color with phenolphthalein. There are differences of opinion as to whether the cleansing (detersive or detergent) action of soap is altogether chemical or physical or a combination of both. When the hands or a fabric have been grossly soiled, as with lampblack or soot, it will be found that

(a) Cold water takes off but little,

(b) Hot water is not appreciably more effective,

(c) Water in which a little sodium hydroxide has been dissolved is but little better,

(d) Water in which a little oleic acid has been placed is not at all efficient,

(e) Cold water, followed by treatment with the cake of soap to form a lather is quite effective,

(f) Soaking in hot water, followed by rubbing with the soap direct to form a lather, is the most efficient process of the lot.

Even the use of soap solutions does not seem to be as effective as the direct application of the soap to the skin or fabric. The greatest efficiency seems to be realized just when the soap undergoes hydrolysis.

Floating soaps are lighter than water because of generally containing sufficient air mixed with the soap proper to give it the desired degree of lightness. The fact that it floats makes it less elusive in the bathtub and washtub, but adds nothing to its value as a cleanser.

While we have been discussing soaps Mrs. Housekeeper has gone downstairs and lighted the gas in the kitchen range and put the coffee percolator over the fire, and, also, because this is Monday (washday) she has lighted the gas in the stove connected with the hot water tank. The burners of the gas range being near the top and hence easy of access, she has never had any accidents while starting fire in that part of it, but on one occasion she had quite a serious explosion when attempting to light the gas under the baker, and another time she had a blowup when lighting the gas in the hot water heater. In both instances she had allowed considerable time to elapse between the time she turned on the gas and the time she tried to light it, with the result that the stoves were filled with a mixture of air and gas in just the proper proportions to form a dangerous mixture, and when the flame of a match or lighted taper was brought into contact with it there was a violent explosion which in the one case blew off the lids of the range and gave her the fright of

her life. In the other case the door of the stove was thrown violently open and the force of the explosion, together with the scare she got from the burst of flame accompanying, resulted in her being thrown half way across the room and left sitting on the floor wondering what "struck her." Since then she has "played safe" and has always had a flame ready to "touch off" the gas as soon as she turned it on.

In this connection it might not be out of order to say a word or so with reference to the habit some people have of trying to hurry a fire with kerosene. The speaker does not know that there is any perfectly safe way to do this, but there is one very dangerous way to do it, and that is to pour the oil from the spout of a can into a fire in which there are no flames, but only glowing coals. The heat of the glowing coals vaporizes the oil and the resulting gas mixes with air, and the mixture may then ignite from the heat of the coals or may have to be ignited with a match. In either case very disastrous explosions are apt to ensue. Many, many good housekeepers have gone to untimely graves by the "kerosene route" and many others have been disfigured for life, while numerous homes have been reduced to ashes because someone tried to hurry a fire with kerosene. If one is careful to have a flame, as of burning paper or wood, in the stove before putting on the oil, and if the oil is dashed on in small quantities from a small cup, the danger of explosion is very much lessened, but there is still the danger of having clothing ignited from the rush of flame; so that, all in all, the process is fraught with danger.

Breakfast this morning is to consist of fruit, a cereal, fried potatoes, fried eggs, and coffee, the preparation of which for the table involve no chemical reactions which we shall stop to consider. But when Mrs. Housekeeper goes to the bread box she discovers that it is empty, not an unusual thing in many homes on a Monday morning when there has been unexpected company on Sunday. She lives too far away from a bakery or grocery to be able quickly to obtain a supply, so there is nothing else to do but stir up a batch of batter for griddle cakes, and again she is dabbling with chemicals and starting some reactions among them.

If she uses one of the more or less popular brands of "pancake flour" or a so-called "self-raising flour" she will be making use of an intimate mixture of flour (possibly of several kinds of grain), egg powder, milk powder, and a baking powder, which mixture needs

only to be moistened with the proper quantity of water or milk to be ready for baking. If the mixture was a good one when made, and has been kept dry, her chances of turning out a satisfactory lot of cakes are good, provided she does not belong to that class of housekeepers whose devotion to, and worship of, their husbands is measured by the frequency with which they set "burnt offerings" before them.

If she follows a formula of her own in making the batter she may use for leavening (making light) the mass, in lieu of a baking powder, either

(a) Baking soda and cream of tartar, or

(b) Baking soda and sour milk or buttermilk.

In either case her chances of turning out a satisfactory batch of cakes are considerably lessened, several factors contributing to the uncertainty. In household practice small quantities of powders are measured by use of teaspoons and larger ones by use of cups. There is a lot of uncertainty in measuring out teaspoonfuls, particularly if a recipe calls for heaping teaspoonfuls. What one person considers a heaping teasponful may be as much as twice that which another would use. Then again teaspoons vary considerably in capacity, and the teaspoon used by the originator of a recipe may have an entirely different capacity than the one used by the user of the recipe. It should go without saying that in measuring materials for a given batch the same spoon, or one of the same capacity, should be used throughout the process, and that as nearly as possible the heaping (if heaping is called for) should be of the same degree with all powders used.

A useful table of equivalents is

Two teaspoonfuls make one dessertspoonful.

Two dessertspoonfuls make one tablespoonful.

Four tablespoonfuls make one wineglassful.

Two wineglassfuls make one teacupful.

Two teacupfuls make one tumblerful.

Two tumblerfuls make one pint.

As an experiment it is suggested that those present tonight who are housekeepers each select one of each of the above articles from their stock, and with water see how nearly the above is true with their set. Very few will find an approximately good set.

Again, different lots of many dry powders vary in density, either because of difference in density of the particles making up the powder

or because of differences in packing (loose or shaken down), so, while a teaspoonful of one lot of baking soda, for instance, may be just enough to neutralize a given bulk of cream of tartar or sour milk, the same bulk of another lot may be either too much (if the powder is dense) or too little (if the power is light) for the purpose intended. If too much, the end product (the cake) may have a decidedly disagreeable alkaline taste, as the excess of baking soda when heated, as in baking, is decomposed in part, with the formation of sodium carbonate, a common commercial variety of which is known as washing soda. If too little, the cakes may taste sour because of the unneutralized cream of tartar or sour milk. This latter condition is to be preferred to the former, as the sour taste is less objectionable than the alkaline taste, and can be more easily masked by the taste of the butter and syrup with which the cakes are usually eaten.

Buttermilk and sour milk vary in degree of acidity with different lots, so their use makes the cake process even less certain of successful outcome than where cream of tartar is used. The first cake off the griddle may be sour, in which case Mrs. Housekeeper usually decides to add more baking soda to the remaining batter; or the cake may be bitter, in which case she adds more sour milk. In either case she has to guess at the amount to be added. If she adds soda she first mixes it with water and stirs the solution into the batter; if she adds more sour milk she is adding water (milk being mainly water); so, in either case she is making the batter thinner (perhaps too thin to hold the leavening gas), and, in mixing, she is stirring a lot of gas out of the mixture. Result, a watery, thin, flabby cake which tries the patience, possibly, of an exacting selfish husband, and sometimes results in a verbal explosion on his part which may constitute the first step of a journey to the divorce courts.

Some housekeepers have the mistaken idea that the sole reason for using baking soda with sour milk or buttermilk is to neutralize the acidity (sourness). If that were the case sweet milk without baking soda would be preferable. The acid of the milk (chiefly lactic acid) decomposes the baking soda (sodium bicarbonate) with the liberation of a gas (carbon dioxide) which puffs up the mass in which it is formed, even in the cold, but particularly when the mass is heated (heat expands all gases). The neutralization of the acid is only incidental. For this reason it is bad practice to mix the soda

with the sour milk and thus run the chance of losing most of the desired gas. Much the better plan is to mix the soda, flour and other dry ingredients thoroughly, generally by putting them through a sifter several times, mixing this with the water or sweet milk called for by the recipe, and adding the sour milk or buttermilk the last thing with only enough stirring of the mass to ensure the even distribution of the latter through the mass. Too much stirring disengages a lot of gas from the batter and lessens the chances of the baked cake having the desired degree of lightness.

A baking powder consists of an intimate mixture, in correctly balanced proportions by weight, of baking soda (sodium bicarbonate, $NaHCO_3$) and some other substance (usually acid in character) to react with it to liberate carbon dioxide (CO_2) gas, together with starch as a diluting material. All the materials should be dried thoroughly before mixing, and packed in containers of such character as to ensure the mixture being kept dry until used. So long as no water comes into contact with the mixture there is no reaction between any of its components, but when it is stirred into water or milk or mixtures containing water the soda reacts with the other active ingredient to form the gas above mentioned (carbon dioxide), the formation of this gas being the sole useful function of a baking powder. To ensure a maximum degree of lightness in a cake or biscuit from a minimum quantity of baking powder, the powder should be mixed with the flour and other dry ingredients and the water, milk or thinning liquids added last, stirred in quickly so as to form at once a relatively thick batter which will hold the gas. Recipes which call for both baking powder and baking soda are scientifically wrong, unless they also call for some other ingredient of an acid character. While it is true that baking soda alone imparts lightness to a mass, it forms (as stated earlier in this paper) washing soda with its strongly alkaline taste and character; hence it should be used only when there is some other substance present which reacts with it. The speaker has seen recipes calling for cream of tartar without baking soda or other neutralizing agent, and fails to see any chemical reason for such use. It certainly cannot produce lightness in the mass and it has a sour taste (not very pronounced, it is true).

The taste of a cake or other product, in the making of which a baking powder is used, depends in considerable measure upon the character of the products resulting from the reaction between the

several active ingredients of the powder. The carbon dioxide, being gaseous, is probably all driven off by the heat used in baking, but each powder leaves in the baked product some one or more non-volatile compounds which may or may not have a pronounced taste, coverable or not by the flavoring agents in the product, or used with the product when it is eaten. Let us look into this phase of the subject.

Alum baking powders contain as active ingredients, sodium bicarbonate ($NaHCO_3$) and some one or more of the aluminum alums [$AlK(SO_4)_2$, $AlNH_4(SO_4)_2$, $AlNa(SO_4)_2$]. When these react they form aluminum hydroxide [$Al(OH)_3$] a tasteless substance (because insoluble in water), sodium sulphate (Na_2SO_4) a readily soluble salt with pronounced disagreeable taste (this substance is sold in the drug stores under the name of Glauber's salt, or horse salt). In addition, potassium sulphate K_2SO_4 is formed when the first alum mentioned is used, and ammonium sulphate $(NH_4)_2SO_4$ when the second is used. The taste of these is not as pronounced as they are less soluble in water than is the sodium sulphate.

Tartrate baking powders contain as active ingredients, sodium bicarbonate and cream of tartar (potassium bitartrate, $KHC_4H_4O_6$), or tartaric acid ($H_2C_4H_4O_6$) or both. The non-volatile residue is either potassium and sodium tartrate, $KNaC_4H_4O_6$ (sold in the drug stores as Rochelle salt), or sodium tartrate $Na_2C_4H_4O_6$, or both. The taste of the product is not so pronounced but that it is generally well covered by the flavoring materials of the cake or its dressing.

Phosphate baking powders contain as active ingredients, sodium bicarbonate and either mono-calcium phosphate [$CaH_4(PO_4)_2$] or monosodium phosphate [NaH_2PO_4]. In either case disodium phosphate (Na_2HPO_4) with a rather pronounced taste is formed. Where the calcium salt is used there is less of the disodium phosphate formed, some of the phosphate radicle going into the formation of tricalcium phosphate [$Ca_3(PO_4)_2$], a tasteless substance because insoluble.

It may be noticed that most of the soluble substances named are laxative or cathartic in physiological action (depending upon the amount taken), but the amount present in a plate of griddle cakes or a piece of sweet cake would not ordinarily be sufficient to produce any appreciable effect on the eater. However, if little Johnny knew this he might insist on substituting cake for castor oil on those occasions when mother imagines he needs medicine of that kind.

The speaker once knew a man who insisted that his wife put Epsom salt into her buckwheat cake batter. He never heard whether or no the wife and children of this man cared particularly for buckwheat cakes.

Baking ammonia, sometimes called hartshorn, but generally sold as ammonium carbonate, though only in part a carbonate, is used in the making of some kinds of cookies. When it decomposes in the baking process it liberates both ammonia gas (NH_3) and carbon dioxide (CO_2) gas, both of which tend to give lightness to the cookies and then disappear, leaving no solid residue in the cake, a desirable thing.

Occasionally one finds a recipe for cake (Angel's food, for instance) in which no leavening agent is mentioned. In such cases there are usually to be used large quantities of egg white which is to be thoroughly whipped. In the whipping process large quantities of air bubbles are enclosed and when the cake is being baked the desired lightness comes from the expansion under the influence of heat of these air bubbles.

Well, breakfast is over and Mr. Housekeeper and the children have gone for the day, the former to his place of business, the latter to school; all of them happy if the cakes were good, or sulky if the cakes were bad. Mrs. Housekeper now turns to the task of clearing off the table and washing the dishes. If she has a supply of hot rain water or other soft water, the cleansing of chinaware and glassware offers little difficulty, as only a little soap is needed to aid the water in loosening the foreign matter, even grease, that sticks to the dishes, aided generally by gentle rubbing with a cloth or brush. The brush is the better as its use makes it possible for the dishwasher to go through the process without having her hands in the dishwater an undue length of time, with all that that means to a sensitive skin. Dishes which had contained pickles and other materials of an acid character should be rinsed in clear water before being brought into contact with soap or soapy water, as the acid (generally acetic) of vinegar decomposes soap to liberate, among other things, the fatty acids of the soap, which are greasy and stick to china and glass.

As the dishes are taken from the wash water they are set on edge in another pan or on a rack which can be lifted out of the pan, and hot water is poured over them to rinse off the adhering soapy water. If the water is hot enough and soft and the draining is properly done there will be little or no need for drying towels, except,

perhaps for the glassware, and then chiefly for polishing. Soft water leaves no residue and the heat of the dishes is generally sufficient to effect the vaporization of the last traces of moisture.

If the water is a river water, a well water or spring water, it is apt to be "hard"; that is, it will likely contain certain substances in solution (generally salts of calcium or magnesium) which react with soaps to form insoluble calcium or magnesium soaps of the acids of the soap used, these being sticky and adhering easily to dishes or fabrics with which they come into contact, and often forming curdy precipitates in the water in which they formed. These deposits are not soluble in hot water, hence cannot be rinsed off. Besides, the mere evaporation of such hard waters leaves a deposit which is easily visible on glassware and may be sufficient to dim the lustre of chinaware. The use of drying towels, or polishing towels, at least for glassware, becomes a necessity, for reasons of fastidiousness, though not necessarily for sanitary reasons. From a sanitary point of view air-drying of dishes is far more desirable than cloth-drying.

The problem of keeping metallic tableware in a presentable condition is one which has given Mrs. Housekeeper considerable concern. Silverware, whether plated or solid, nickel-plated ware, German silver (which, by the way, is not silver at all but an alloy of nickel, copper and zinc), steel, and even aluminum, all tarnish—lose their lustre and very often turn yellow, brown or black. The tarnish on silver is usually silver sulphide and may be caused by a number of things. Eggs and certain vegetables (cabbage and similar vegetables) contain organic sulphur compounds which, as the material becomes old, or often when it is being cooked, decomposes, giving off, among other substances, hydrogen sulphide (H_2S), often called sulphuretted hydrogen. Most coal contains sulphur compounds which, under conditions of imperfect combustion sometimes yield this substance and often it finds its way into the atmosphere of the home. It is a gas possessed of an odor which no sane person would suggest as a basis of perfumery, and it attacks the surface of many metals, particularly silver and copper and alloys containing them, charging them superficially into sulphide which is usually dark and lustreless. The chances for considerable quantities of the gas getting into the air of the home and remaining there are much greater in winter than in summer, and so it is that silverware requires polishing oftener during the cold months than during the warm ones of midsummer. The odor of boiling cabbage is in part due to this gas,

and the tarnish imparted to silver spoons when used with eggs, particularly when said eggs are not strictly fresh, is also due to it.

Silver and other smooth metalware may be, and generally is, cleaned of tarnish by use of polishes and pastes containing a so-called abrasive—something which mechanically rubs off the tarnishing film. For silver and other relatively soft lustrous metals nothing should be used that is gritty. Emery, pumice, sand and sandsoaps, steel wool, are all too hard and scratch the surface of the metal. Chalk, china clay and rouge (a special form of iron oxide) are most generally used, sometimes with a grease base, sometimes with water, sometimes with ammonia water. Every time metal tarnishes a thin film of its surface is changed to sulphide or some other compound, and each time it is polished or cleaned this compound is removed and, where mechanical polishes are used, almost always, if not invariably, some of the underlying metal is also removed. This explains why plated ware eventually shows the baser metal which makes up the body of the article, particularly on the edges. The oftener such ware is polished the sooner will the baser metal show. Even so-called "solid silver" (which, by the way, is not pure silver but an alloy of silver and a harder metal, generally copper, "Sterling silver" being ninety-two and one-half per cent. silver and seven and one-half per cent. copper) gets thinner with each trip through the hands of the polisher.

Occasionally one meets with a silver polish which contains potassium or sodium cyanide. They seem to be very effective but they not only remove tarnish but some of the silver underneath, and, besides, these cyanides are intensely poisonous, hence dangerous for the laity to use.

Perhaps the most satisfactory process for cleaning silver is that involving the use of the "silver clean pan," in which, by chemical means (electrolytic) the silver compound which is the cause of the tarnish is decomposed with the formation of metallic silver, while there is no evidence that any of the other silver of the article is removed. The pan may be an ordinary aluminum pan, or it may be an enameledware pan with a sheet or grid of metallic aluminum covering the bottom. The tarnished silver articles are so placed as to be in contact with the aluminum and covered with a solution of salt and baking soda in water, and then heated. A tablespoonful of salt and a teaspoonful of baking soda to each quart of water works very nicely.

Mrs. Housekeeper has quite a collection of aluminumware among her cooking utensils and has found this metal very satisfactory for most purposes. She has learned by experience that there are some things which she dare not do with it—that she dare not put strongly alkaline solutions into it, that hydrochloric acid attacks it quickly, and that it is not altogether immune to the action of vegetable acids. She does not wash it with strong soaps and she does not use soap powders and similar preparations on it, as these destroy its lustre and leave a deposit on it which readily takes up colors from colored fruits and vegetables. When she wants to polish it she usually uses steel wool, and when she wants to remove stains from its interior she is usually able to do so by putting into it some water and a little vinegar and boiling the mixture.

The dishes out of the way and the water in the boiler being hot, Mrs. Housekeeper begins on the weekly wash. In sorting over the various soiled articles she finds a tablecloth with coffee stains on it, a napkin with fruit stains on it, a handkerchief with writing fluid on it, another napkin with several iron rust spots on it, another handkerchief with blood spots on it (Johnny had had the nosebleed), and a soft collar with iodine stains on it (father had "doped" an incipient boil with iodine and got some on his collar). These all demanded separate treatment before she dared put them into the tub with the rest of the "white clothes." She removed the blood stains by washing them thoroughly in cold water, the coffee and fruit stains by pouring scalding hot water from a height onto the stained fabric stretched over a bowl, the iodine stains by treatment with a solution of sodium thiosulphate (commonly called "hyposulphite of soda"), the iron rust and writing fluid stains by treatment with a solution of oxalic acid followed by treatment with a solution of chlorinated soda (Labarraque's Solution, sometimes incorrectly called "Javelle water") made from "chloride of lime" and washing soda. Sometimes she uses lemon juice and salt to remove iron stains. When stains are on colored goods Mrs. Housekeeper knows that the chemical which removes certain stains may also remove certain colors from the goods, so she always tries it first on an inconspicuous part of the fabric before "going after" the stain proper.

Mrs. Average Housekeeper is not fortunate enough to have a supply of naturally soft water with which to do her washing, else she could do satisfactory work with almost any good laundry soap. The water supply in her home is not even temporarily hard water,

else merely boiling it would decompose the acid carbonates which make it hard, and the normal carbonates, being insoluble in water, would give her no trouble; but the water she has to use is permanently hard (contains calcium and magnesium salts, generally of sulphuric and hydrochloric acids, which are not decomposed by heat). These, as stated earlier in this talk, react with soap to form insoluble soaps which curdle the water solution of soap, the clots adhering to the clothes and the sides of the tub, and very often form nuclei upon which is deposited bluing from the rinse water, forming spots on the clothes. She has found that she can neutralize the effects of the substances which make the water hard by putting some washing soda (salsoda) into the water before she puts any soap into it. Washing soda is sodium carbonate (Na_2CO_3) and has the property of reacting with calcium and magnesium salts and converting them into water-insoluble carbonates, thus rendering them inert. It is cheap and there is nothing better for the purpose. Many of the water-softening powders on the market under more or less fanciful names are chiefly this substance with occasionally some powdered soap mixed with it. It is cheaper than soap and has some detersive action of its own, and has little or no effect on the strength of cotton and linen. However, neither it nor any other alkaline material should be used on wool or silk, as alkalies have a strong tendency to destroy both kinds of fiber (especially silk) and are claimed to bring about shrinkage in woolens.

Many laundry soaps (only yellow ones, however), are in part a sodium resinate (because made in part from rosin) and these usually lather very freely, making an abundant suds which is very effective in loosening dirt. So-called "naphtha" soaps rarely contain enough naphtha, particularly after they have been stored a while and allowed to dry out, to warrant their use in preference to any other good soap. Some people imagine that a little kerosene or turpentine oil (spirits of turpentine) added to the wash water, or more frequently to the water in which white goods are to be boiled, is of value.

There are differences of opinion among housekeepers as to the value of "boiling" clothes with strong soap solutions, some claiming that it tends to keep them white, others that it does no good. Several things are to be said in favor of the practice. The hotter the solution the greater the degree of dissociation on the part of the soap and the greater the amount of suds, which has the property of loosening dirt; and boiling certainly sterilizes the articles boiled. Mrs.

Housekeeper has a good wringer and sees to it that the rolls are close together when she uses it, thus ensuring the squeezing out of the most of the soapy water from the articles before they are put into the rinse water. She has also learned that hot water removes soap better than does cold water and is not so uncomfortable to work in with her hands, so she always has her rinse water quite warm. She is one of those who uses a little bluing in the rinse water for the white clothes, knowing that it has a tendency to neutralize slightly yellowish tints; but she has found that some blues on the market are worse than none at all—that unless clothes once blued with them are thoroughly rinsed in clear water before being put into soapy water (the next time they are washed, for example) the blue adhering to the fabric is changed by the alkali of the soap into a yellow compound which is harder to cover up with bluing than was the original slight yellow tint, and the continued use of such a bluing makes the clothes so yellow that they have to be bleached by special process if they are to be considered as being white. Mrs. Housekeeper will have nothing to do with any bluing that loses its color and assumes a yellowish or brownish tint when a solution of it in water is treated with either ammonia, washing soda or strong soap.

Besides using only neutral soaps with woolens Mrs. Housekeeper takes care not to rub them on washboards or tumble them about very much in washing machines. She knows that wool fiber has a lot of barb-like projections on the surface and that these have a tendency to make adjoining fibers mat together when rubbed together when wet, and that these barbs do not allow of the threads stretching out fully again. She also believes in the practice of washing and rinsing woolens in water as nearly as possible of the same temperature, as tending to prevent shrinkage.

When she can do so Mrs. Housekeeper always arranges to hang her clothes on the line to dry in such a way that the white clothes shall be in the sunlight and the colored clothes in the shade, the former to get the bleaching action of sunlight, the latter to avoid it.

Mrs. Housekeeper having "hung out the clothes," put away the tubs, etc., and mopped the floor where she had been working, retires to her room to rest for a time before preparing dinner; and we, being somewhat tired ourselves from following her about, will leave her there, with the hope that the rest of the family, when they come home, will realize what a hard day she has put in and will be ready to excuse her if she does not have quite as fine a dinner ready for them as she usually has on other days of the week.

THE UPS AND DOWNS OF NITROGEN

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IT IS an unwise preacher who commences his sermon with an apology for his choice of a text—although we have all listened to sermons where an apology was quite appropriate, not only at the beginning but also at the Amen. Yet for sedative purposes it is now publicly announced that the grammar of this title is not the most fortunate, and with due deference to that bewildering and bewildered crowd of cross-word puzzle devotees, the title is hereby changed to "The Verticals and Horizontals of Nitrogen."

This element, Nitrogen, discovered in 1772 by Rutherford, is one of the most peculiar of the elements constituting the periodic table. Of the great group sitting at the elemental banquet table none is more eccentric than this gas called Nitrogen. There is not an adjective in Webster's that is not or can not be properly applied to this erratic element at some time or another. Antonyms and synonyms come in complicated pairs to describe its queer eccentricities. Inert and active, fettered and free, toxic and tonic, worthless and worthy, devilish and demure, vagabond and docile—all fit into the various whims and fancies of this most versatile of the silent builders of the universe. It is the Dr. Jekyll and Mr. Hyde of fact—among the elements.

And indeed it is because of its versatility and its complexities of conduct that it will be difficult to do aught this evening but consider a few phases of its endless story.

Nitrogen was born in the Kingdom of Infinity, a long time before the creation of Adam. That is obvious for it was one of Adam's several ingredients. Who or what its progenitors were is not clearly known, for its name is not mentioned, even in that long genealogy in Genesis. A hint has been dropped, however, by the Darwinian chemists of today, who claim it to be a lawful son of Hydrogen. As a matter of fact it seems that Hydrogen will eventually prove to be the Abraham of all the elements. At least it ap-

pears when we brush out the heap of heavy words—isotopes and emanations Mullikan and gamma rays and the like—the master design in the pattern of the element is always the hydrogen sitting in positive comfort on the throne of every atom, whether that atom be lead or gold or nitrogen. Thus what we actually know of the origin and genealogy of Nitrogen is as accurate and trustworthy as the chart of John Jones or William Williams.

It is nevertheless very interesting to note that the modern physicist has exploded for all time the honored concept of the changelessness of the element, of the eternal integrity and independence of the fundamental substances. But while the element is no longer immutable—the old law of the indestructibility of matter still reigns unquestioned.

The atmosphere about us is roughly composed of one-fifth oxygen and four-fifths nitrogen. Of course there are many things in the air other than these. The composition of the atmosphere is as heterogeneous as that of sea water. There are the rare gases—helium, neon, krypton, niton, argon, and many others—then the transient end gases of combustion and other indescribable emanations—there are the limitless armies of germs that travel their invisible ways in search of roosting places—the air in truth is full of polluting things, and fuller today than ever, and probably more polluted since in addition to its regular impurities the radio has come with its jazz and its kindred sophistications.

Yet the gross character of the air is fairly constant. Thus it is assumed that when Jacob wrestled with the Angel at Bethel and thereby raised the tension of his alveolar air—the atmosphere there was even as it is today—four-fifths of nitrogen and one-fifth oxygen. This evening in Philadelphia we breathe the same air that millions who are now in dust have breathed before, and the millions who will follow us will again use this nitrogen that we unwittingly, at every expansion of the lungs, draw in and empty out again with every expiration.

In other words the nitrogen which we breathe is not directly used in any sense in our bodies. It comes into our lungs through our noses, stays in awhile, looks around and goes out again exactly as it entered. And instead of being able to use this nitrogen, which is as free as raindrops in April, when our bodies need nutritional nitrogen we go out to the delicatessen shop and pay 85 cents a dozen for eggs embalmed by experts. The oxygen which goes to

the lungs with it of course attends to its several businesses—but nitrogen, the lazy, is only a silly wanderer.

Now, one might ask, what good is this atmospheric nitrogen if it is inert, inactive and unconcerned, incapable of assimilation by plant or animal? Our answer is a question. What good is ballast to a plying vessel or sand in the ascending balloon?

Let oxygen alone be breathed in our lungs and our fires would burn so fiercely that the furnace itself would crumble. Oxygen indeed is a supporter of combustion and the quintessence of vitality, but unless diluted with the inert, inexplosive, harmless nitrogen, it is a vile poison.

Then one might ask why it is that this free Nitrogen insists on remaining "up in the air" all the time. Again we counter with a question. Why does Ivory Soap float? The manufacturers say it is because of its purity—we know it is because it is lighter than water since it is composed of a great deal of air surrounded by a little soap.

So nitrogen is up in the air because as long as it remains Nitrogen its density is such that it cannot help but float in the ethereal spaces.

It must not be assumed, however, that Nitrogen's contribution to the scheme of existence is merely its ballasting or diluting properties, for besides its occurrence in the free and inert state in the atmosphere, a small amount of it actually comes to earth—and circulates in inorganic and organic nature. This bringing of Nitrogen to earth is effected by Nature in several ways, all of them designed to hang something heavy on to the Nitrogen and so force it down by sheer gravity.

To the operation of living processes, to the growth of plants and animals, this nitrogen of earth is vastly more significant than the nitrogen of the sky. For without its circulation the earth would be barren of vegetative or animal life. It is indeed an essential part of all vital processes.

Peculiarly enough, however, Nature has been most conservative with her supply of these Nitrogen compounds in and upon the earth, for she knows how difficult it is to keep combined nitrogen behaving properly, and so rather than be bothered with it in quantity she wisely uses a "shift" system that keeps a small force of it busy all the time. Of all the merry tricks displayed by Mother Nature, none

indeed is more fascinating than her method of handling the nitrogen compounds.

Scientists of course have to give this scheme of hers a special title, so they call it "The Nitrogen Cycle" or Circle.

Now, it is very hard to know just where to break into a circle—whether it be a social, a sewing or a scientific circle. There are no protuberances upon which to hang—and if the circle is in motion one is so apt to go off at tangents and forget to come back. It is pardonable, then, if, in trying to get on this merry-go-'round of Nature's, we have to run with it in the same direction, and perhaps about it several times before we can finally find some place of entry.

First of all let us understand two things very distinctly. Number one—the Ups of Nitrogen. Inactive, inert, ballasting, diluting—Nitrogen of the air. While in the air it is of little use, though filled with possibilities.

Number two—the Downs of Nitrogen, the compounds of Nitrogen. This is fixed nitrogen, nitrites, nitrates, ammonia, protein, etc., not up in the air, but in and upon the earth—vitally necessary to the welfare of the earth's energy, space and time binders—namely, the plants, the animals and human beings.

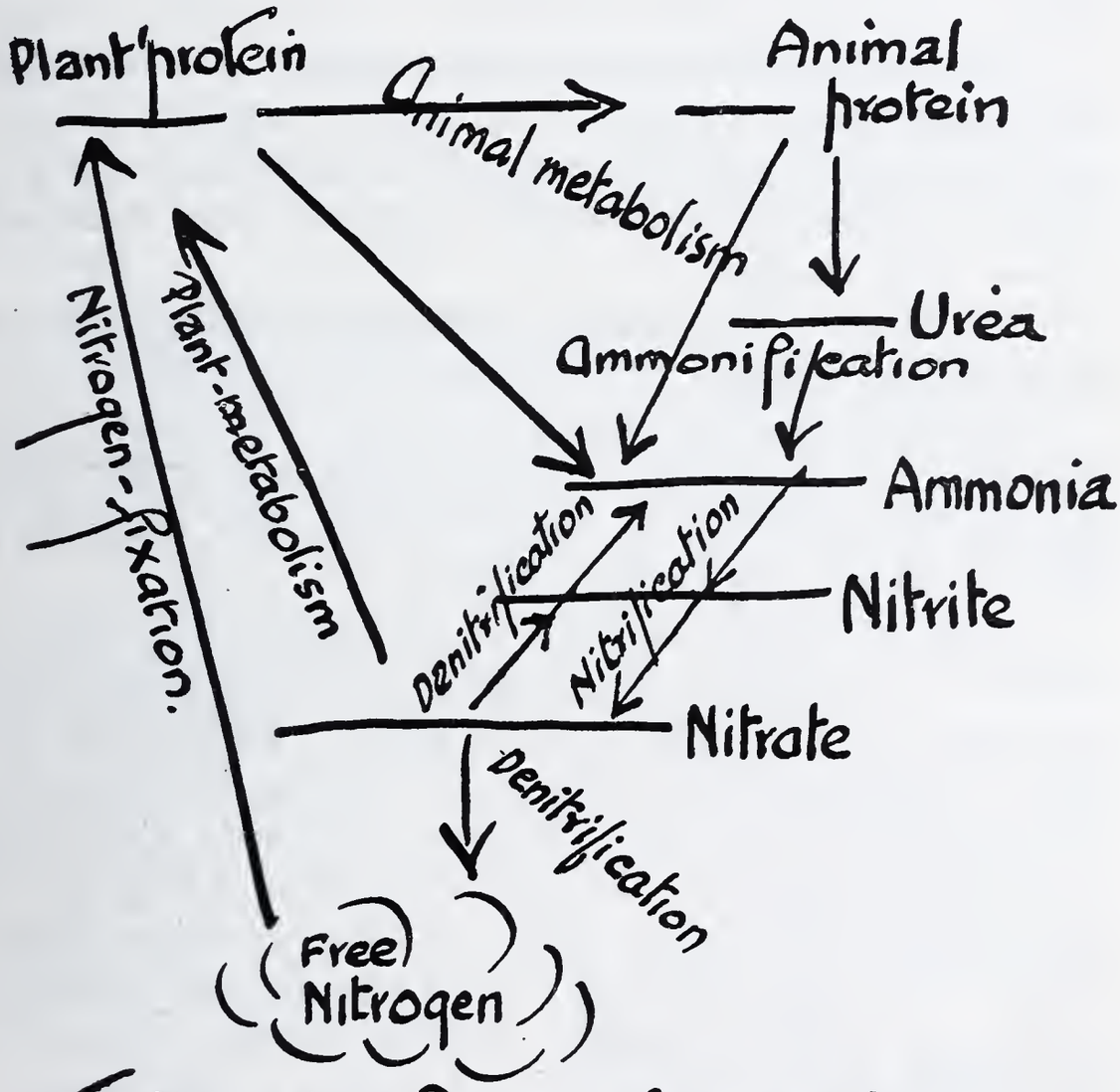
Let us now try to break into the circle like this: Teacher told us many years ago, and it must have been true for it is still being so taught—that in the human diet are three necessary components, namely, fats, sugars and proteins. These three and all three must constitute food if the fed is to survive. The last named (protein), is a complicated nitrogen compound. It forms part of our food because it forms a large part of our body structure. Out of it are knit the fibers of our muscles, the plasma and cells of our blood stream, the substance of our nerves and brain.

But the muscles and blood and nerve and occasionally the brain are constantly wasting their substance through action—and this wastage must be repaired by new construction. That in part is where the protein of our food must go, and that is why protein in food is so vitally essential.

Animals and some plants contribute to man this necessary part of his diet. Man of course is the elect of earth—he says so himself—and everything in and upon its surface was put there for his especial welfare, and so these things are only a matter of course.

The lean meat of animals, the nitrogenous portions of plants and vegetables, milk, cheese, albumen of eggs and other commodities

furnish man with this valuable protein. But where do the animals and plants get it? We are still on the trail of the cycle. The animals get their nitrogen by eating the plants, that is one reason why a cow is contented, for it eats conscientiously so that it can function well as a milk, butter, cheese and meat factory for the benefit of mankind.



The Nitrogen Cycle (squared!).
Showing the transformations Nitrogen undergoes in Nature.
From Conns' Bacteriology

The plants, then! Where do they get the nitrogen? For let us continue to remember that life even in the plants cannot go on without these nitrogen compounds. Out of the sky and out of the soil—that is where plants, the energy binders of the universe, withdraw their vital nitrogen.

The commuter generally regards his little garden back of the house with more affection than information. To his sweet state of unconcern the soil that covers the surface of his 20 x 20 plot is a sort of an anchorage for pansies and poppies, lettuce and radishes. A sprinkle here of radish seed and a dash of lettuce there—then a little water now and then, and out of the mud comes the huckster's wagon.

This does not apply to a certain resident of New Jersey who was recently asked why he did not make a vegetable garden. His reply was that he preferred to depend on his huckster for his vegetables, for when this person was asked for beans he never gave Jimson weed instead.

But the soil is more than an anchorage for plants. For it feeds them the vital nitrogen. That is part of its contract.

But where does the soil get its nitrogen compounds? That indeed calls for a complicated answer, although it is still within the cycle that we shall find it. Into the scheme now enters the tiniest agent of all, the ever-present microbe.

Plants call to their assistance a great variety of microbes for this business of garnering in the nitrogen. And these germs work their mysterious ways in several types of service. There are all kinds of bacterial sub-contractors in this job of building the elemental blocks of nitrogen into the larger inorganic compounds which the plant needs for its laboratory. One special squadron of bugs will capture free nitrogen from the air, treat it in some mysterious manner and quietly turn it over to the plant, no longer the lazy nitrogen but a working agreeable compound.[1] Another wrecking crew of germs will take in charge a fallen leaf or branch or a dead bug or a dead man or a fallen tree trunk. For they all spell alike to the germs. Slowly but surely they will tear it apart, reducing its complicated nitrogen compounds to useful and usable substances which the living plant can use. Nature has no use for dead organic matter.

Her germs are always on the job disposing of worthless carcasses. The only way to stop her is to fill the carcass full of something of which the germs are afraid. That is why the embalmer tem-

[1] These symbiotic germs, so called because they enter into a business partnership only with those plants that suit them. Thus the leguminous plants, peas, beans, etc., are especially fortunate in that these germs of nitrifying especially favor them. And these full-grown legumes soon grow rich in nitrogen, hence the fertilizing value of cow peas.

porarily frustrates decomposition by filling the corpse with formaldehyde.

In the soil these hordes of microbes all have their special duties to perform. Nor would one of them depart from its conventional activities. Each has its special work to do and a nitrifying bacterium would no more think of doing else than nitrify any more than a Philadelphia union plasterer would fix a leak in the cellar.

Between them, however, they manage to take nitrogen from the air, out of decomposed nitrogenous tissue, out of decaying plants and animals, and they build it half way or tear it down half way, into a fixed and useful nitrogen compound, just right for the plant's metabolism.

In its own laboratories, then, the plant builds these compounds furnished by the germ or other source into the complicated molecule of protein which directly by way of the earth or via the cow or chicken gets into the constitution of man who seems to be the center of the circle or cycle. And man must not draw too much inferential comfort from this peculiar story that seems to place him high in Nature's estimation. For Nature, after building this intricate cycle especially for man's benefit, claims as part of her relentless scheme the very being for whom her cycle operates.

Let Life desert this fragile human temple, rot and decay soon start their decomposing work. The germs of putrefaction are no respecters of persons and a kingly shroud deters their wrecking enterprises no more than the beggar's coverlet. The silent dissolution of the material flesh proceeds with equal regularity and relentlessness in Potter's field and in the marble vaults of Croesus.

Nature demands again the ingredients that she loans to the soul's repository, and she is more anxious about her fixed nitrogen than any part of the carcass. Of course every atom of the body is put to another use. Let none of my listeners be misled into thinking that death is the end of even material things.

> "There is no death.
> The dust we tread
> Shall change beneath the summer showers
> To golden grain or mellowed fruit,
> Or rainbow-tinted flowers."

Personally this soliloquy affords me no regret. I hope in her scheme of things that Nature does with my atomic residues what

the poet intimates so beautifully. I hope the wrecking germs that take over the job of disintegrating my carcass do their job right and return all my nitrogen into active circulation again. Only I hope that daisies and not nettles will have the benefit of it.

May I pause here to remind you that this great process of exchange which goes on and on eternally has in it much that urges meditation. For example, is it appreciated that the luxuriance of growth in the cemetery is due to the fertilizer planted there in serried rows, the decaying bodies of the silent sleepers?

Is it appreciated that the sweet geranium that grows on a loved one's grave mound is actually part of the body that lies then beneath it? Is it appreciated that cremation is a crime? For those who burn their dead are robbing the earth of much potential fertilizer. If cremation was universal the earth would lose each century practically twenty bodies to every square mile of surface area. It is right to believe that such a procedure would have considerable effect on the fertility of the soil in a few millennia more or less.

Nor is this bacterial army and plants the only instruments which Nature uses to produce and keep in circulation her Nitrogen compounds, for there are additional factors at work. Atmospheric electrical discharges cause the nitrogen and oxygen of the air to lose their usual incompatibility in the shock of the explosion. In the presence of moisture they become companionable and join hands, forming a mutual association known as ammonium nitrate, which is conveyed to earth wrapped up in raindrops.

Then the plants themselves, so we are told, by a process of surface evaporation form small amounts of a fixed nitrogen compound called nitrite of ammonium.

Another source of available nitrogen compounds is in the bodies and in the excrements of animals. In the animal economy the protein nitrogen which enters into the diet is not all used in the construction of new tissue and repairs, and much of it passes out of the circulation with some of the nitrogen unused, although greatly simplified. The presence of these simplified nitrogen compounds in the dead bodies of fish and other creatures and in manure and other animal excrements account for the use of these materials as plant fertilizer. Human urine contains a large amount of urea, which is a simplified nitrogen compound very close to the inorganic kingdom. The value of animal manures, loam, vegetable mould, marl, decayed animal material, etc., has been recognized long before our re-

corded history. For even the poor Indian knew that a dead fish stuck in the corn hill gave him a better crop of corn. That it was the nitrogenic substances present in these manures and moulds which gave them much of their plant food values was not known, however, until recently.

In England, in 1669, Sir Kenelm Digby suggested in place of manure the use of saltpeter, which he said constituted the valuable part of manure. Liebig, of extract of beef fame, was, however, the chemist who first really brought to light the true principles of fertilizer practice, and he demonstrated in 1840 that certain chemicals, notably the nitrogen compounds, phosphates and potash salts, were equally as good, if not better, than manure for fertilizing barren soil.

Dr. Slosson, in his wonderful book, "Creative Chemistry," is responsible for the statement that people laughed at Liebig and transferred the syllables of his name when he said that some day the world would have a nitrogen famine unless some way was found to use the nitrogen of the air to feed the crops that were essential to the earth's necessary hordes.

At the present time this country alone produces more than five billion bushels of grain each year. Each bushel of grain needs nearly a pound of nitrogen for its growth. This means that the soil of the land loses annually to its crops about two and a half million tons of nitrogen compounds. This loss must be made up by using fertilizer or by planting leguminous crops, or the soil will inevitably become exhausted and fail to produce our food.

As if storing up for a day of dearth, Nature had quietly banked quite a vast accumulation of this treasured useful nitrogen compound in the form of excreta in a most remote quarter of the earth. Off the coast of Peru lie the Chincha Islands, one of Nature's Nitrogen Banks. Here for countless centuries great hordes of silly-looking birds, the penguins and pelicans, and other birds of the sea, have lived in a most insanitary way. Their filth and excrement have accumulated through these untold ages until some of the deposits have reached heights of almost two hundred feet. Later similar guano piles were discovered on the mainland of Chile and Peru.

It is interesting to know that in certain guarded islands upon this coast annual accumulations of guano continue to occur to the extent of about 50,000 tons. One dabbler in useless arithmetic figures that it requires the digestive equipment of four million

pompous penguins or a like number of pensive pelicans to deposit this vast accumulation.

Fixed nitrogen in the form of sodium nitrate, so-called Chile saltpeter, constitutes the great portion of these accumulations. These stores had been made possible because of the lack of rain in that part of the world, thus the soluble nitrate had not been washed away into the sea where most solubles finally go.

But once this bank was discovered man promptly went to looting it, for his children had multiplied so rapidly on this earth that the soil which nourished his crops was sadly in need of nutrition. He also had need of it in the business of fighting. What was put in the ground was caught in the swirl of the cycle, but the nitre that was shot out of guns went back to its freedom and inertia again.

Gunpowder, smoky and smokeless, are all forms of combined nitrogen. With every shot from a firearm life is destroyed, whether the bullet or shell strikes its victim or not. As previously mentioned, no life is lost by the death of the individual, for out of the dissolution of the body new life arises. But the shot of the gun releases, each time, a vast amount of free nitrogen, which disappears into the air and inertia again. There is a diminution each time in the capital of fixed nitrogen, and it is upon this that the total number of living beings actually depends. Then the burning of the forests and the ammoniacal decay of organic materials also scatter much of the fixed nitrogen back into its state of freedom. And so the rotation of Nitrogen in Nature goes on eternally. And what a romance could be woven out of just one chapter of this everlasting exchange. Listen to this fragment from the autobiography of an atom of Nitrogen:

"For many years I roamed in delight out in the high ethereal spaces, my twin atomic brother ever flying by my side. We had always been warned not to get too close to what father called the Region of the Noisome Light, because it was said that freemen were there made slaves. Religiously we kept away for many atmospheric æons. One day, however, an argon molecule who had been to the Region and back, delighted us so with his story of wonders and wonders, that we both quietly decided to go there. And silently riding a globule of water we stole away one day to the Land of the Terrible Flash.

"But oh! the sadness of it then, for even on the very boundaries of that terrific region there flashed the most ungodly sheet of fire,

followed by a crashing noise the like of which I had never heard before. Long ago my brother Atom and I had sat on the edge of a Lunar Crater when it spouted a column of fire and smoke, and what a noise that was, yet it was but a swish of an angel's wing to the thundering clamour of the Land of the Noisome Light. And what a confusion—millions of other atoms like ourselves—for we were not the only sons of Nitrogen who had ventured to explore—and none seemed to know where to go or what to do. My brother was only a moment since grasping my hand for assurance. After the flash he was nowhere around, and vainly I cried and hallooed for him. Then came another flash, worse than the first, and a noise like the crash of a thousand falling stars.

"For the first time in my life I was hopelessly lost. Blinded by the white light and deafened by the splitting noise, I groped about for company. In the dismal darkness I grabbed the next one to me, and not content with one I grabbed another. But when senses lost their bluntness once again I learned my sad predicament. No longer a freeman, wielding a will of my own—knight of the sun-lit ether—I awoke to a sense of bondage.

"Oxygen—the hateful, hated son of a laborer—held me doubly captive. Nor had I my wonted confidence or capabilities. No longer could I sit on the back of a raindrop and guide it wherever I would, but I seemed now to sink and be enthralled by it—and I recall how, enveloped in water and tied to the oxygen, I tumbled to another far land, which I now know as the Planet of Earth. This Earth, I find, is spoken of in its own books as the favored of the Lord's handiwork, yet the Chamber of Commerce in Mars only refers to it as an insignificant, lightless star infested with two-legged insects.

"I had no idea in my mind except to get back home to my brothers, no matter what road would occur. So, with this notion always in my heart, I splashed with the raindrop into the sea off the coast of the land called Norroway. Something instinctively told me then to keep on the right side of green-colored beings, and surely enough, as I approached a tall columnar creature, swaying in the off-shore winds and waving long white arms into the pulsing sea, I felt an irresistible impulse pervade my being—and I was drawn into the embrace of this, a Fjord sea grass.

"But you can imagine my sadness then, upon finding that this meant for me a much more certain imprisonment, for in addition to my bonds of oxygen the plant which they call the seagrass added

to my captors a host of other cruel atoms. There was hydrogen and carbon and phosphorous—nasty, disagreeable, unrelenting captors, and in the plant's metabolism I was only one insignificant member of its chlorophyllic content.

"Then the sea one day became angry, and threw ragged stones and sharp pieces of sand at the green plant where I was imprisoned. The blade of grass where my cell was fell before its onslaught, right

into the seething waters, and before I knew it I sailed right out to sea. But I was still in the unrelenting grasp of that chlorophyllic molecule.

"A little eel was searching for its breakfast in the sea of the Skaggerack when he spied my prison blade, and before you could count one, two, three I was down deep in his funny gullet. The funniest hotch-potch you ever saw was in that queer stomach—the

leg of a daddy-long-legs, a sea-urchin's chin, a piece of raw shad roe, and my blade of grass. Among us we soon learned that freedom was still far off, but all of us nitrogen atoms never talked or thought of anything else.

"The amenities of assimilation had it that my chlorophyllic molecule was reorganized and I next found myself more or less permanently lodged in the pancreas of the eel, with some other nitrogen prisoners, occupying a little island called the Langerhans all to ourselves, where we led a sort of a sweet existence. All of a sudden that erratic eel took an instinctive notion to travel and so, without even kissing good-bye to its mother, it slipped its way through the narrow fjord and headed for the high seas. Soon I found that there was method in its madness, for it developed that the eel was off to school. And what a school I found it to be. Millions of slimy little wrigglers capered about, apparently without design, yet headed for some fixed objective. How like, thought I, those schools in the land of the two-legged race.

"Ultimately, and I still was on the island in the pancreas of the eel, we came to that objective. It was the western coast of Chile. Norroway had been Chile enough for me, but I naturally went where the eel went. What I cannot understand, however, is the ridiculous notion that sent that silly eel all the way from Norway to this South American shore just to serve as a breakfast for the first fool seabird that happened along.

"We came upon Chile late one spring evening and our host the eel, instead of resting comfortably in a bed of warm alluvial mud, insisted on climbing to the surface of the sea just to get a little air before retiring. The first thing we molecules knew a great winged monster bumped against the ocean, grasped our eel in its claws, transferred it to a great yellow trunk, painted like an American Store, and from there slid it into its stomach. I was now on the inside of a bird called the pelican, so named, I am told, because it fits into a certain 'Wiley' nursery rhyme.

"Again I knew I would change my prison, although I had as yet no hope of freedom. The silly bird's alimentary processes, for some peculiar reason, did not choose this time to use my molecule for tissue building, and I was soon discarded as a worthless excrement.

"Piled high on this dreary island, where the Sun was always hot and raindrops never came, I suffered long imprisonment. I

knew my bonds were not so tight as in the sea plant prison, or in the eel's pancreas, but yet my hopes grew less and less until a Yankee sail ship came along one day and carried our humiliated molecules into the vessel's hold. There I heard I was part of guano and that instead of being bonded to carbon and hydrogen and such, my captors now were sodium the kind, and the everlasting oxygen, that hated son of a laborer.

"The Yankee ship carried me far from the sullen shores of the South to a place called Philadelphia, where this guano was greatly appreciated, for I conceitedly remember them saying 'it has a lot of nitrogen in it, and it is fine to speed the growth of plants.'

"Next I remember being wrapped in a paper bag and a two-legged being called man carried me to his home in the suburbs. Of course, then, I could not understand why that silly idiot took me all the way from the big city to a place called Smithtown just to sprinkle me on the ground in his back yard. Now, of course, I know why he did it. Along with me in the earth he carefully put a number of little round black grains, and after he had buried every one of them in a little hole in the ground he gently patted the earth over them, sprinkled them with my guano, passed unkind words about the odor of my person, and went back to the house perfectly well satisfied with himself.

"The first thing I knew, the same irresistible urge that I sensed off the coast of Norroway, when I first saw the sea grass, came over me again, and I was drawn to that little black grain which by this time had opened and had stretched out a lean long arm. Here again I thought I caught a glimpse of freedom. I divined the plan of the two-legged man and I knew that the little black seed would grow to a plant—and that is just what happened. It was but a little while that I found myself, yet sorrowfully so, part of a complicated molecule, in the cell of a nice red radish.

"Shortly, on a Sunday morning, the man came into his garden, roughly pulled from its earthy moorings my radish prison, and carried it and a few others proudly to his kitchen door. There he offered his collection to a busy person who was getting dinner ready.

" 'John,' said this pretty busy person, 'I hardly think it wise to eat radishes with oysters and bananas and ice cream and ginger ale and buttermilk and cottage cheese, as we have for dinner today, they might kill you.' I heard every word of it.

"But John, as Johns generally do, disregarded the sweet person's advice, and, enclosed in the root cell of a red, red radish, I took another trip to a stomach.

"Talk about the hotch-potch in the eel's stomach—and the pelican's bill of fare—John's stomach had them all beat for variety, for it was not only a delicatessen shop, but it had the wares of the drug store man and the hardware merchant as well.

"The next part of my story is sad—but it is short. Listen—John died, the next day, of too many radishes, or too much ice cream. Anyway, he died of acute indigestion.

"But oh! the gloriousness of it all—John was a Garibaldi though he did not know it, for in his will was written the declaration of my independence. He wanted to be cremated, and like all his living desires so was his desire in death gratified by that pretty person whom he left behind. Out to Stenton Avenue in Philadelphia the remains of John were carried. There they put him in an oven and turned on the gas.

"My happiness was unbounded. I knew that the heat of combustion would melt away my bonds. I feared not the warmth of the vessel in which they destructively distilled poor John—for I knew it would give me my freedom. The shackles were finally broken—and out of the chimney I scooted—and I never stopped until I reached once more the freedom of my father's land.

"Here, odd to relate, I found my brother atom, who had returned before me and whose wanderings in what he called the 'Cycle' had been quite as strange as mine. Only the great difference was that he had broken his bondage in quite another way. For a chemist had linked him with glycerin in a very strong combination, and when a shell in which he was stored exploded in France, one morning, the shock was so great that his captive chains were shattered and he flew back to the air again. Never again will my brother and I visit the land of the Flash for we relish our freedom once more."

But still we have not proceeded far with the story of Nitrogen, particularly with the important part which it has occupied in shaping the destinies of the world in recent years.

Nitrogen started upon its most bloodthirsty course when someone in Europe learned that nitre had explosive possibilities when mixed with soot and sulphur.

It is said that China knew this secret when Europe was still in knee pants, but the simple-minded Chinese never thought of using it in warfare—they saluted their gods with it—it made a noise which even a wooden Buddha might hear.

But the Europeans bridled it in a different way. They packed it in guns and covered it with pieces of lead. When the power exploded the lead was propelled at a fearful pace and only stopped when it struck something solid or spent its force in air. Occasionally it performed its mission and found lodgment in the body of a human being.

The English first used it at Crecy, and scared the French so badly that they actually licked them. Then along came a Frenchman who with the usual Gallic sense of refinement invented a powder that was smokeless and ashless—much more satisfactory than the dirty old gunpowder. This powder was made by combining glycerin and nitric acid, a compound of nitrogen.

And all of these improvements that came along contained Nitrogen in its new man-killing role. After smokeless powder came the

high explosives such as guncotton, a compound of cotton and nitric acid; then cordite from guncotton and nitroglycerin. The inventor of cordite was Nobel, of prize fame. Oddly enough, during the great World War, while Nobel's cordite was blowing humanity to Einsteinian fractions, the commission was awarding the prize given by his estate to "men prominent in the promotion of peace." Then came more nitrogenous death-dealers as lyddite and melenite and TNT.

And so we see that the demands of peace as well as the demands of war were high for Nitrogen. Indeed, between burning his stores of coal and wood—all of which contain fixed nitrogen, by burning instead of burying his brothers, by shooting it out in guns, by turning his sewage to sea, man for years had wasted his capital of fixed nitrogen.

Then along came the terrible World War where more fixed nitrogen was wasted by a day's firing of a Black Maria or a Jack Johnson from Krupps than could be stored up by a million dysenteric pelicans. Germany before the war had accumulated vast stores of nitrates. Her preparedness along this single line had long convinced chemists of her perennial itch for war. Huge stores of Chilean guano and saltpeter had been imported. In 1913 alone she purchased nearly a million tons.

So when war did come Germany was well supplied with explosive compounds. Yet when the English fleet off the Falkland Islands sent the German ships to the bottom of the sea and then bottled her warships at Kiel, it closed at once to Germany the nitrate beds of Chile. But even this did not deter the fighting German, and with an invention that came from America, he found another nitrate bed far paramount to Chile's.

With the pounding guns of the Aisne and the Marne blowing his nitrates back to the sky, and deprived of imported supply, the German scientist did what the world had failed to do in all its previous history. He reached to the sky for his nitrogen. Banished from the seas and hemmed in by land, he had only the sky left to him, and necessity once more brought invention.

Bradley, the American chemist, was the first to steal nitrogen from air and fix it in the form of useful compounds, just as the germ does or the thunderstorm. But he was not given much encouragement. Then two Norwegian chemists, Berkeland and Eyde, aided by the bountiful water supply of that land, took up the prob-

lem and produced nitrogen compounds so cheaply that it was sold on the Pacific Coast at a price lower than the Chile saltpeter.

Then the war came and the German chemists took hold of this problem. How well they accomplished it under the stress of war is answered by the statement that had they not been successful the war would have terminated long before it did.

At the conclusion of the war Germany was meeting the greater part of her nitrogen requirements by air nitrogen fixation. If her morale and man-power had answered the test of time as well as her chemists did, the war, unhappily, might still be going on.

Today there need be no further anxiety concerning the world's supply of nitrogen compounds, for in many countries there are great factories producing fertilizing and other nitrogen compounds in vast quantities, and so cheaply that their product can compete successfully with what fixed nitrogen Nature chooses to accumulate in her several savings banks.

These methods of nitrogen fixation are distinctly chemical or at least physico-chemical processes, although in practically every case they are patterned after Nature's own methods. Careful description of them at this time is out of the question, and yet, in conclusion, a brief review of the principal methods will not be amiss.

The three processes now in operation on a paying scale are referred to as the arc, the cyanamide and the direct synthetic ammonia process. There is another method now in operation in this country on a more modest scale, whereby the air nitrogen is fixed as sodium cyanide and hydrocyanic acid—that powerfully toxic compound of nitrogen, so toxic that a student is alleged to have described it as being "so very poisonous that one drop of it placed on the tongue of a dog would kill a man."

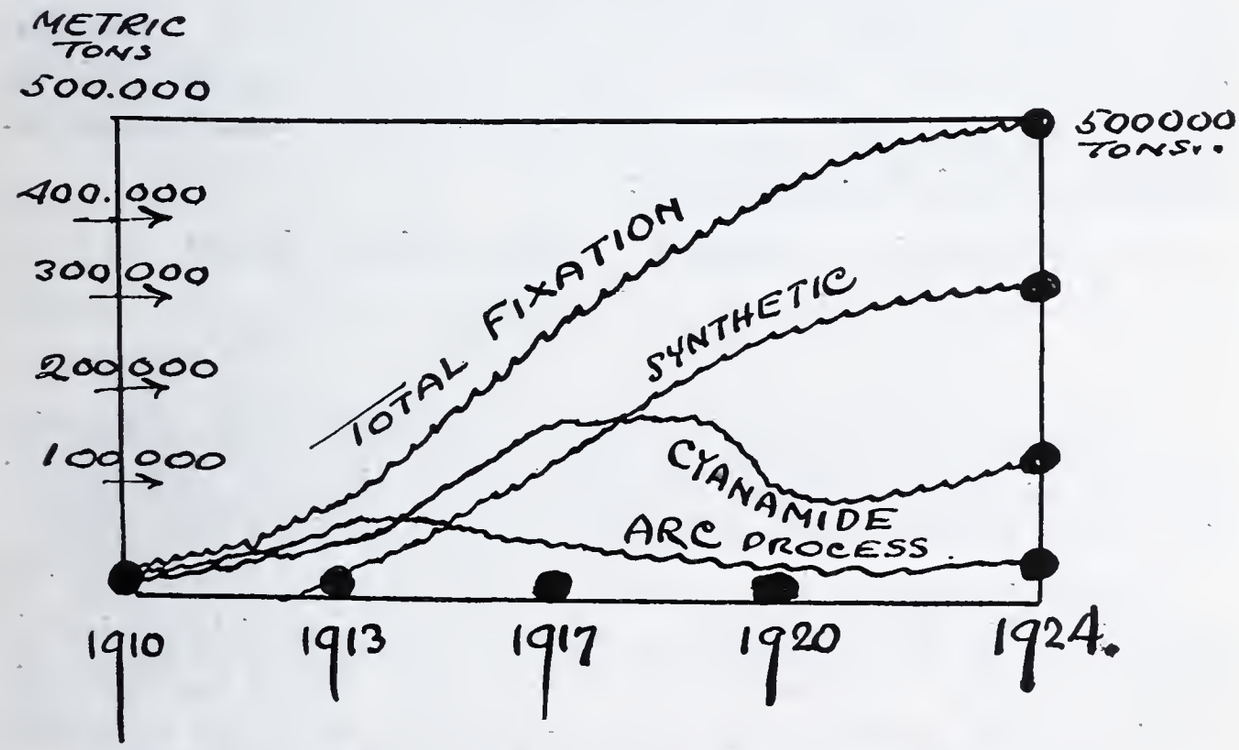
The arc method is patterned after Nature's lightning method of fixation. For every metric ton of nitrogen fixed by this method 68,000 kilowatt hours is the power requirement. Thus its successful operation demands cheap power. Hence its use in Norway, where there is a vast amount of potential water power.

The cyanamide process, whereby nitrogen is fixed by combination with finely powdered calcium carbide at comparatively high temperature, produces a compound rich in nitrogen, and one that is available with much less power than is used in the arc process.

Muscle Shoals, which Henry Ford coveted but failed to get, had a cyanamide plant with an annual output of 200,000 tons of that

compound—the largest plant of its kind in the world. The world's present output of cyanamide is down to 140,000 metric tons annually.

Lastly we come to the direct synthetic process, which is now accepted as the most successful of all the processes. This consists in forming ammonia directly from the nitrogen of the air and hydrogen secured elsewhere. This is known as the Haber process, and union of the elements is accomplished by a process of catalysis, using uranium or platinum or iron dust or other metal as the catalyst. The agent that performs the catalytic union behaves very like a parson. Indeed, a catalyst has been termed a "chemical parson." When a young couple finally decide that two can live as cheaply as one (although, as the wise ones know, that is a proven mistake, for the



OUTPUT OF NITROGEN FIXATION METHODS COMPARED.

only two that can live as cheaply as one are a dog and a bug on his back. The bug pays nothing for his food or his transportation) so when the young couple decide to go it together, they call on the marrying parson. Then a brief ceremony consisting of compromising "yeses," the parson whispers the ominous benediction, and the union is accomplished. But the parson henceforth enters not into the life of the wedded parties. He simply effected the union and the ingredients of the union soon go home and forget him.

So it is with a chemical catalyst. It performs the union of chemicals without itself being involved in the bargain, except as the

agent of the reaction. And so in the Haber synthetic process air is liquefied by pressure and cold—then the nitrogen is boiled off at 194 degrees C., leaving the oxygen behind for other useful purposes.

Hydrogen, the other party to the marriage, is produced from water, which is almost as cheap as air. The water is passed over red-hot coke and the hydrogen is glad to lose the company of its erstwhile coworker oxygen. Then the nitrogen and hydrogen, mixed in the proportion of 3 to 1, are strongly pressed again and heated to about 700 degrees C., and passed over the finely divided uranium, the catalyst. By this means is obtained a large yield of ammonia.

Then, if it is desired to change the ammonia, which is volatile, to a fixed compound, this is done, again with a catalyst, by changing it by the so-called Ostwald process into nitric acid. The ammonia gas and air (containing oxygen) are heated together and run over heated platinum gauze which plays the part of the parson according to the following scheme:

Ammonia		Oxygen		Nitric acid		Water
NH_3	+	$2O_2$	=	HNO_3	+	H_2O

Using the direct synthetic process, the Germans alone during the war had an annual nitrogen compound output that was in excess of the normal amount produced in Chile, namely, half a million tons.

But my story has been already too protracted and probably too indefinite. Yet the subject is one where "going around in circles" is quite excusable. And so I bring it to a close. Much has been left unsaid because of unkind time and my kind regard for my audience's comfort. Some day, perhaps, another opportunity may come when I can again return to the subject and tell the rest of the story in a more complete and more entrancing fashion.

ANIMAL AVIATORS

By Marin S. Dunn,
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IN THESE days of wonderful improvements in aviation, it is with increased interest that we turn our attention to methods of flight developed in the various phyla of the animal kingdom. The term "animal" is used in this paper in its broadest sense and is not confined to mammals alone. It is common knowledge that most insects and birds fly. Insects we know, are more numerous than all other terrestrial animals, and birds, also, are more numerous (12,000 or more species) than other terrestrial vertebrates. Therefore, from the standpoint of number of species, the ability to fly is the rule for land animals. This power as we shall see has arisen independently at different times in various groups.

In addition to those animals possessing true flight (insects, birds, bats), certain other forms although they cannot be said to truly fly, are nevertheless capable of gliding or parachuting movements. Their bodies are not sustained in the air by volitional wing beats as in the case of the insect and bird but they are equipped with some type of apparatus for gliding or sailing through the air. To the last mentioned type of animals belong the flying frog, flying dragon, flying squirrel, flying squid, flying lemur, flying gecko, flying phalanger, and possibly the flying fish.

It is the purpose of this paper to discuss briefly in the following taxonomic order those animals which have the power of true flight or of gliding movements.

Phylum *Mollusca*—flying squid.
Phylum *Arthropoda*—
- Class *Insecta*—insects.
- Class *Arachnida*—ballooning spiders.

Phylum *Chordata*—
- Class *Pisces*—flying fish.
- Class *Amphibia*—flying frog.
- Class *Reptilia*—*Pterosauria,* flying gecko, flying dragon.
- Class *Aves*—birds.
- Class *Mammalia*—flying phalanger, the flying lemur, bats including the flying foxes, the flying squirrels.

Flying Squids.

These animals are members of the Phylum *Mollusca* to which belong the snail, the oyster, the octopus, etc. They have elongate cylindrical bodies with terminal joined fins. At the head end, there are four pair of shorter arms equipped with suckers and one pair of long tentacular arms. *Ommastrephes illicebrosus,* Verrill, the Short-finned Squid, occurs in our northern Atlantic waters where it feeds on schools of herring and mackerel. The prey is caught by the arms of the squid and killed by biting in the back of the neck. Squids are attracted by light, and they are caught in numbers by the fishermen of New England and the St. Lawrence (Rodgers, 11) who either row out in boats with bright lights and after attracting the animals row toward shore where the squids ground themselves, or they may directly place lights upon the shore and capture the creatures as they swim in. Squids are thus captured by the thousands and used as bait for the larger sea fish. Flying squids have been known to rise from the ocean and throw themselves upon the deck of low vessels, the leap being fifteen to eighteen feet above the water.

Insects.

By far the most numerous of the flying animals are the insects. These little creatures, unless they attract our attention by some unpleasant effect such as the Clothes-moth, the Mosquito, the Boll Weevil or the Japanese Beetle or inspire our curiosity by their strange form as the Praying-mantis or unless they cause our admiration by their magnificent coloration as some of the dragon flies, butterflies and beetles, often pass unnoticed. Insects are air-breathing *Arthropods* having a distinct head, thorax and abdomen, a pair of antennae, three pair of legs and most frequently one or two pair of wings in the adult state.

The wings of insects are at first soft little sacs permeated by breathing tubes. In the pupal stage, they grow out from the sides of the thorax above the insertion of the legs. After transformation has occurred and the pupal skin is thrown off, the wings expand with air and enlarge to many times their size. Packard (10) defines the wings of insects as simple expansions of the crust, spread over a framework of horny tubes. These tubes are really double, consisting of a central trachea or air tube, inclosed within a larger tube filled with blood and which performs the functions of the veins.

Hence the aeration of the blood is carried on in the wings, and thus they serve the double purpose of lungs and organs of flight. The wing is divided by its veins into cells. The terms "costa," "subcosta," "radius," "media," "cubitus" and "anal" are names given to principal longitudinal veins. The venation of the wing often plays an important part in our system of classification. It is interesting to note that specialization may result in either the reduction by the atrophy of veins or by the coalescence of two or more adjacent veins or by the multiplication of the principal veins.

Insects usually have two pairs of wings. One pair attached to meso—and one pair to the metathorax. In certain groups, however, these may only be one pair, generally the anterior as in the *Diptera* or order of the flies. Through lack of use, both pairs of wings may degenerate, a condition we find in fleas and bird lice.

Wings of insects vary greatly in the different groups. Often the front wings may be modified into protective coverings such as we see in the *Orthoptera* and more especially in the *Coleoptera* or beetles. Thus the horny elytra of the beetle are really protective modifications of the fore wings. In the *Diptera* or flies, the hind wings form a pair of beautiful balancing organs, the halteres.

The color of insects is due to (1) structures which cause interference of light, (2) internal pigments, (3) a combination of both. Folsom (4) states that "the iridescence of a fly's wing and that of a soap bubble are produced in essentially the same way. The wing, however, consists of two thin, transparent, slightly separated lamellae, which diffract white light into prismatic rays, the color differences depending upon differences in the distance between the two membranes." The straited scales of a butterfly wing act like diffraction gratings and produce the beautiful colors we know. In the case of the *Coleoptera,* small lines or pits often cause the diffraction of light. Colors due to internal pigments formed by the cells below the outer cuticle are often seen in the form of hypodermal and cuticular pigmentation. This may be seen easily in our common potato beetle. In other cases, the beautiful colors may be due to combinational effects.

It has been found that the tip of an insect wing describes an elongate figure "8" the wings of the two sides beating at the same time. We may easily see this for ourselves if we fasten a small bit of gold leaf to the tip of an insect wing and allow the wing to be freely vibrated in the light while held against a dark cloth. As a

rule, the smaller the insects wings, the more rapid the rate of vibration. According to Folsom, a butterfly (*P. rapae*) makes nine strokes per second, a dragon fly twenty-eight, a sphingid moth seventy-two, a bee one hundred and ninety and a house fly three hundred and thirty.

The success of insects as a group may be in large measure attributed to their development of their powers of flight, and their ability to be blown by the wind. In distribution, they are almost worldwide from the Arctic to the Antarctic circle. They are found on high mountains (*Emesa* sp. recorded in Ecuador at 16,500 ft.), in caverns, hot springs, deserts and a few in salt water. Some beetles, dragon-flies and butterflies, etc., migrate at certain times in immense numbers.

Spiders.

Certain spiders although they have legs may also use the wind for the purpose of travelling from place to place. Their method of locomotion is like that of a balloon or dandelion seed. On warm fall days, the young spiders climb to the top of a convenient post, twig or herb and lift their abdomen, spin their silken threads. After a time, if there be sufficient breeze, the animal floats away buoyed up by the silken mass in the current of air. Comstock (2) speaks of the showers of gossamer that result when numbers of these spiders attempt to fly when the wind is too strong and the threads are not carried up but blown against some nearby object. He adds: "On one occasion I saw a ploughed field that was covered with a sheet of silk. It was evident that an immense number of small spiders had attempted to fly but that the wind had blown their threads merely from the crest of one furrow to another. Although the field was completely covered with the sheet of silk, so delicate was this fabric that it was invisible except where the light of the sun was reflected directly to the eye of the observer; the appearance being like that of the wake of the moon on slightly disturbed water."

Flying Fish.

The power of journeying through the air has been developed principally in two widely separated families of fish, the *Exocoetids* which are soft-finned and unarmed, and the armed *Dactylopterids*. Their power of suspension in the air is brought about by the remarkable elongation of the pectoral fin rays and an extension of the in-

terradial membrane (Fig. 1). The pectoral muscles, on the other hand, are but little more developed than in those fishes having normally strong pectoral muscles. This is in marked contrast to the pectoral muscles of birds.

The members of the *Exocoetidae* are well fitted by form for travel both in air and water. The sharp cut front and the subfusiform shape is of great value. The long lower lobe of the caudal fin allows great power to be given to the jump as the fish leaps from the water. According to Gill (6), there are about twenty species in American seas. Important among these are *Cypselurus xenopterus, C. californicus* and *C. callopterus* of the Pacific and *C. gibbifrons* and *C. cyanopterus* of the Atlantic. These small fishes (the length of adults of different species about 8 to 18 inches) swim in schools propelled by strong, sweeping strokes of the posterior end of the body and the tail.

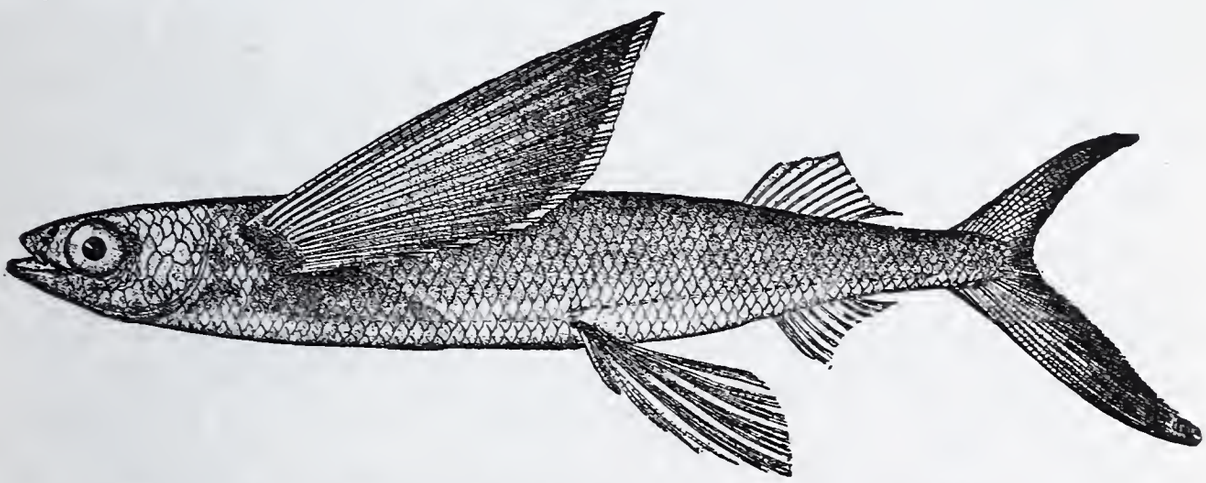

FIG. 1—CALIFORNIA FLYING FISH (Cypsilurus californicus). Nature Library. Fishes. Jordan & Evermann.

Their food consists of crustaceans, molluscs and various small fish. They are preyed upon by dolphins, sharks and large fish. Probably many species spawn far from land although they have been recorded in about the rocks of Chincha Islands on the coast of Peru.

The *Dactylopterids* or flying Gurnards with oblong shaped heads are covered with hard-keeled scales. The pectoral fin has a short anterior lobe. They are essentially bottom fish often touching supporting objects with down pointed ventral fins. *Dactylopterus volitans* is an inhabitant of the Atlantic Ocean. The back is brown with dark spots, the sides rose with silvery reflections and the outspread wings have rows of black and white eye-like spots. *Dactylopterus* possesses the power of changing its color from light to dark or vice versa. Many observers have never seen them fly, but on the

other hand, Moseley of the Challenger Expedition observed them rising to a height of about a foot above the water and flying fifteen to twenty yards. Undoubtedly, their diet is one of small crustaceans and tiny fish.

There is great difference of opinion as to whether flying fishes really possess true flight. Möbius, Boulenger and others believe that flying fishes have no power of volitional wing beats and that their flight is merely a powerful jump followed by a continued parachuting with outspread pectorals until the fish lands with a splash. On the other hand, Jordan and Evermann (9), however, state: "Probably the differences in opinion are largely explained by the fact that the different observers have studied different species. Some species, at least the larger ones have a real flight; the pectoral fins vibrate, and the flight can be prolonged almost indefinitely." Later we read: "The senior author of this work dissents from this common view expressed above, and does not believe that the pectoral fins have any large power of motion of their own, but that they quiver or vibrate only when the muscles of the tail are in action." Moseley watched Flying Gurnets move their wings rapidly in flight. Hankin (7) who has seen a flying fish make a sharp turn round the transverse axis as it reached the top of a wave, observes: "When we consider the distances covered by flying fishes, their high speed, and the apparent uniformity of the rate at which they move, it becomes difficult to accept this view" (*i. e.*, that flight merely consists of a jump out of the water lengthened out by the supporting power of the wings, and that there is no extraneous supply of energy or propulsive effort, and that the animal falls headlong into the water as soon as its momentum is exhausted). The last-mentioned investigator thinks that flying fish obtain energy from the air in the same unknown way as does the soaring bird.

Flights of 450 and 800 meters have been recorded.

Flying fishes furnish excellent food and because of this, they are eagerly sought for in certain localities. Gill (6) in his report, quotes the following passage concerning flying fish catching (*Cypselurus speculiger*) in the island of Barbados. The fishing grounds are "little more than 10 or 12 miles from home" some not more than five. "There are about 200 boats engaged in the fishery. Nowise notable for grace of form or elegance of rig, they are substantial, undecked vessels of from 5 to 15 tons capacity, built in the roughest manner, and furnished in the most primitive way. The motive power is a gaff mainsail and jib and a couple of sweeps for calms. . . .

The fleet leaves the 'canash' (harbor) before daybreak, each skipper taking his own bearing and working for the spot which he thinks will furnish the best results. . . . The tackle used is of the simplest kind. A wooden hoop 3 feet in diameter, to which is attached a shallow net with inch meshes; a bucketful of—well, not to put too fine a point on it—stinking fish; a few good lines and hooks and a set of grains, form the complete layout. . . . As soon as the boat is hove to and her way stopped, the usual exuberant spirits and hilarious laughter are put and kept under strong restraint, for a single sound will often scare away all fish in the vicinity and no more be seen that day. The fisherman leans far over the boat's side, holding the loop diagonally in one hand. The other hand, holding one of the malodorous fish before mentioned, is dipped into the sea, and the bait squeezed into minute fragments. This answers a double purpose; it attracts the fish, and the exuding oil forms a 'sleep' or glassy surface all around, through which one can see to a great depth. Presently sundry black specks appear far down; they grow larger and more numerous, and the motionless black man hanging over the gunwale scarcely breathes. As soon as a sufficient number are gathered, he gently sweeps the net downward and toward the boat withal, bringing it up to the surface by drawing it up against the side. Often it will contain as many fish as a man can lift; but so quietly and swiftly is the operation performed that the school is not startled, and it very often happens that a boat is filled (that is, 7000 or 8000 fish) from one school. More frequently, however, the slightest noise, a passing shadow, will alarm the school; there is a flash of silvery light, and the water is clear, not a speck to be seen. Sometimes the fleet will return with not 1000 fish among them, when prices will range very high until next day, when, with 50 or 60 boats bringing 5000 to 6000 each, a penny will purchase a dozen."

Flying Frog.

Ceratin species of true frogs of the genus *Rhacophorus* of the class *Amphibia* are remarkable for the great size of the fully webbed hands and feet which are often used as parachutes. *Rhacophorus* is a large genus with over forty species, one dozen at least in Madagascar, eight or nine in Ceylon, the others in Southern Asia, the Philippines and Malay Islands extending into China and Southern Japan. *Rh. pardalis* (Fig. 2) lives in Borneo and the Philippines. Specimens have been measured and the following values obtained: Total length, 6.5 cm. or 2½ inches, area of one fully expanded hand

3.4 sq. cm., area of one fully expanded foot, 6.0 sq. cm. It has been reported coming down from trees in a slanting direction making use of its webs as parachutes. *Rh. reinwardti* as described by Gadow (5) lives in mountain forests of Java and Sumatra. It has a length of three inches. In color, it is green above and yellow below. Young specimens have blue patches on the webs of hands and feet and behind the armpits. "Besides the flap on the heel and the curious cutaneous fringe on the forearm, suggestive of an incipient flying membrane, the skin forms a projecting fringe on the inner side of the fifth toe and a transverse flap above the vent."

FIG. 2—RHACOPHORUS PARDALIS (From Wallace Malay Archipelago). Taken from Gadow.

Pterosauria.

These animals were flying reptiles of the Mesozoic Era. The fore limbs were modified into wings, and the patagium or membrane was carried by remarkably elongated ulnar finger (Fig. 3). They were rather a distinct group which probably had no relationship to birds even though there are a number of resemblances brought about by their mode of life. The skull presented a few features of the *Rhynchocephalia* and the pelvis, *Crocodilian* characteristics. The hand had four phalanges and the feet five separate toes. Apparently, they reached the height of their development in the Upper Cretaceous and then died. *Dimorphodon macronyx* had a total length of three to four feet. This measurement included the large skull (nine inches) and two-foot tail. The patagial finger was about twenty inches and the entire wing twenty-eight inches. *Rhamphorhynchus longicaudatus* had membranes which extended to the kneee, and the inside of the hind limbs was connected by a membrane to the tail. Even the tip of the tail carried a membrane expansion. Other

genera were *Ornithocheirus, Pterodactylus* and *Pteranodon. Pteranodon longiceps,* from the Middle Cretaceous of Kansas, had a length of skull of two and one-half feet and a spread of wings of nearly twenty feet.

Flying Gecko.

The Geckos are a large family of lizards containing about forty-nine genera and 270 species, confined to the warm parts of the world. They are usually active at night and by means of special structures under the toes are able to climb over trees and walls. The tongue is protrusible and broad. One of the genera, *Ptychozoon* is called the flying gecko because of its almost completely membraned form. These expansions are reported to act as parachutes when the animal is in the air. *Ptychozoon homalocephalum* lives in the Malay Peninsula and adjacent islands.

FIG. 3—RHAMPHORHYNCHUS MUENSTERI (Restored by Marsh). (From Geikie.) Taken from Gadow.

Flying Dragon.

The flying dragons are members of the genus *Draco* of the old world lizards or *Agamidae*. They have a broad, short tongue and the teeth are set on the edge of the jaw bone. From the sides of the body arise a pair of large membranes supported by five or six of the elongated posterior ribs. These expansions may be folded like a fan. *D. volans* of Sumatra, Java, Borneo and the Malay Peninsula is about ten inches in length inclusive of the five-inch tail (Fig. 4). There are three pointed appendages on the throat, the middle one longer than the other two. The upper part of the male has a metallic sheen with dark spots upon a brown ground color. The wings are orange with black markings. Gadow (5) gives the fol-

lowing description: "Certainly they do not fly by moving the wings, but when at rest upon a branch, amidst the luxurious vegetation and in the immediate neighborhood of gorgeously colored flowers, which partly conceal them by their likeness, they greatly resemble butterflies, especially since they have the habit of opening and folding their pretty wings." Hankin (7) states that they can glide forty to fifty meters and do so with a loss of height of about one in four. They have been seen steering to avoid trees, and they probably feed on ants which they catch on the tree trunks.

FIG. 4—DRACO VOLANS (Flying Dragon). From Amphibia and Reptiles, Gadow.

Birds.

Birds are wonderfully adapted for flight. Their hollow light bones, their air sacs, their possession of feathers and their modified fore limbs or wings, placed high up the body, their well developed pectoral muscles, and bodies which offer but little resistance to the air make them remarkably fitted for aerial progress. Birds and feathers are associated inseparably in our minds, but few of us stop to think what a wonderful structure a feather really is. These structures arise from dermal papillae with a covering of epidermis as do reptilian scales, and enveloped in a feather follicle. Hegner (8) gives the following description of a typical feather: This "consists of a stiff axial rod, the scapus or *stem;* the proximal portion is hollow, and semitransparent, and is called the quill or calamus; the distal portion is called the *vane,* and that part of the stem passing through it is the *shaft* or rachis. The vane is composed of a series of parallel *barbs,* and each barb bears a fringe of small processes, the *barbules,* along either side. The barbules on one side of the barb

bear *hooklets* which hold together the adjacent barbs." The down feathers possess a soft shaft and a vane without barbs.

The color of the feathers may be due to chemical causes (pigments within the feathers), to structural peculiarities, or to both. The color of the individual bird varies throughout its life. The color of the nestling bird changes to that of the generally dull, immature plumage. The two sexes often differ in color, and the male is especially prone to bright colors during the breeding season.

In flight the wing works on the principle of the inclined plane, and both up and down strokes propel the bird forward. The wing tip describes a figure eight as it is forced downward and forward, and then upward and backward. Various birds travel at different rates, the carrier pigeon has a racing speed of about thirty-five miles an hour, and ninety miles per hour has been recorded for ducks.

The fascinating subjects of bird classification, nests, song, migration and importance cannot be discussed at this time and the interested reader is referred to many excellent publications concerning them.

Soaring.—Apparently the soaring flight of birds of temperate climes differs from that of the soaring flight of the inland tropics. In the former case, the birds owe their soaring ability to their success in finding and using ascending air current while in the latter, the birds actually avoid such currents. Hankin (7) who has extensively studied among others the "cheel" (*Milvus govinda*) in the Agra district observes that in fine weather there is a definite time at which soaring commences. Apparently within two or three minutes the air becomes capable of soaring flight. Before this time, however, the cheels may be seen in flapping flight. The birds start soaring in order of their loading (weight lifted per unit of supporting area) the heavier the bird, the later their start. As the air becomes soarable, the bird is able to travel horizontally in soaring flight without loss of speed. The soarability of the air may be defined as that condition which enables it to support soaring flight. In his work, Hankin observes two kinds of soarability (1) sun soarability which only occurs in the presence of sunshine and may be present in the absence of wind and (2) wind soarability which may occur in the absence of sunshine. In the latter case, the strength of the wind is not an index to the soarability for some strong winds may be completely unsoarable, and the birds apparently take pains to avoid ascending air currents since they cause instability.

Flying Phalangers.

These small mammals belong to the order *Marsupialia* together with the kangaroos, the wallabies, the opossums, the pouched mice, the wombats, the banded ant-eater, etc. The tail is long and prehensile and the pouch is well developed. There are at least three genera of flying phalangers. *Petaurus* (three species) has parachute-like expansions of the skin between the fore and hind limbs and large naked ears. *P. breviceps* has a body eight inches long bearing a nine-inch tail. *Petauroides,* the second genus has a partly naked tail. *Acrobates,* a tiny animal, is not more than six inches long including the tail.

These forms cannot fly but only parachute down through the air. Beddard (1) remarks that it is interesting to note that the same method of flight has been independently evolved three times, for each of the three genera is specially related to a separate type of non-flying Phalanger.

FIG. 5—GALEOPITHECUS (After Vogt and Specht). From Biology, Parker and Haswell.

Flying Lemur.

This strange animal, *Galeopithecus* (Fig. 5), probably an aberrant *insectivore,* although it has been referred to the lemurs and bats, inhabits the forest of the Philippines and other islands of the Indian Archipelago and also the Malay Peninsula. During the daytime, it hangs head downward like a bat from a limb but at night, it glides through the forest in search of food. It attains the size of a cat, and is remarkable for its well developed patagium or gliding membrane, supplied with muscles. This patagium extends from the neck to the fore limb, from the fore limbs to the hind limbs and from the

hind limbs to the tail. In respect to the degree of development, the patagium is between that of *Sciuropterus* (a flying squirrel) and the bat.

Bats.

Bats are truly flying mammals. Their fore limbs and the fingers particularly are elongated greatly. Expansion of the skin in the form of membranes spreads over this bony framework and connects also with the sides of the body and the hind limbs. Another

FIG. 6—BAT (Synotus barbastellus). (After Vogt and Specht). From Biology. Parker and Haswell.

membrane, also, may stretch in the space between the hind legs and more or less completely connect with the tail (Fig. 6). The knees are bent backwards causing walking to be difficult. The ear has an elongated lobe or tragus, and the nose usually strange complicated membranes. The latter may be due to secondary sexual characteristics or perhaps function as tactile organs.

Bats (more than 600 species), are almost world-wide in distribution and range in size from the big Malayan flying foxes (*Pter-*

opus, with nearly sixty species from Madagascar to Queensland, *P. edulis* has been reported to attain a wing expansion of five feet) to creatures the size of a mouse.

Nocturnal in habit, bats pass the day in hanging by their feet in caverns, hollow trees, old barns, etc. (Andrews has found a diurnal flying fox on Christmas Island.) "In winter many bats hibernate in similar quarters, but there is also a southward migration of certain species, like that of birds," Stone and Cram (12). Their voices are squeaky and high. Two young seem to be the general number among our eastern bats. These are born in July.

The following classification of our American bats is taken from the above-mentioned authors.

I. Leaf-nosed Bats. Family *Phyllostomatidæ.* Size large, tail usually wanting, a curious leaf-like appendage on the end of the nose.

II. Free-tailed Bats. Family *Noctilionidæ.* Size, rather small, tail present but the terminal half free from the interfemoral membrane, projecting beyond it. No appendage on the nose.

III. Common Bats. Family *Vespertilionidæ.* Similar to the last but with interfemoral membrane reaching to the tip of the tail.

Two common species of bats found in the vicinity of Philadelphia are the Large Brown Bat, *Vespertilio fuscus* (Beauvois), which may often be seen in summer and fall about electric lights industriously wheeling and flying in search of its insect prey, and the Red Bat, *Lasiurus borealis* (Müller), with bright rufous fur.

The true blood-sucking bats of which we have heard so many stories are South American and belong to the genera *Desmodus* and *Diphylla* of the family *Phyllostomidæ. Desmodus rufus* is the true Vampire bat. The bloodsuckers are devoid of tail and true molar tooth, but the front teeth are sharp and cutting, and the blood of cattle, horses, etc., is lapped up as it oozes from the wound.

Flying Squirrel.

Any one who has seen these beautiful furry little creatures at home will be eager to learn about their habits and manner of life. But notwithstanding, not a great deal is known concerning them. They belong to the Order *Rodentia. Sciuropterus volans* (Linnæus) has a length of about nine to ten inches, and the skin of the sides of the body may be produced to form a parachute or patagium. They are nocturnal and jump from tree to tree spreading their legs and

thus expanding the parachute to assist them while in the air. The top of a tree with decayed center furnishes them an excellent home. During the day, they sleep in the nest but with evening, they are astir, scampering through the trees as they pursue one another or look for food. They have been known to leap fifty yards from the top of a tree to the bottom of another. Two to four young are said to be reared in the nest.

Pteromys, about twelve species, is an inhabitant of the old world. They are sometimes called flying marmots or flying cats. Their membrane extends from toes to wrist and an additional membrane unites anteriorly the forelimb to the neck and posteriorly the hind limbs to the root of the tail. They are larger than *Sciuropterus* reaching 16-18 inches, exclusive of tail. They live on beetles, nuts, etc., and have been known to jump nearly eighty yards, and it has been said that they are able to steer while in the air.

It may thus be seen that the power of aerial navigation has been developed independently in a number of different groups of animals and also in some cases in the same group (fish, phalangers, etc.). Of course it is easily understood that the groups possessing it have great advantages with respect to dispersal and geographical range. Barriers, otherwise impassible such as oceans, lakes, mountains, etc., are safely crossed. (A cuckoo, for example, is known to spend its winters in Fiji and certain other islands of the Pacific and its summers in New Zealand, travelling in all a distance of about 3000 miles each year. The golden plover travels from the Arctic circle to the Argentine and Southern Brazil and back again each year, a distance measured on its elliptical path of about 20,000 miles.) Flight also is of great value in escaping from enemies and in the obtaining of food. This latter advantage is well shown by the spread of some of our obnoxious insect pests.

It seems fitting to conclude this article with a few sentences by Darwin (3) from his "On the Origin of Species" dealing with the origin and transitions of organic beings with peculiar habits and structure. "Look at the family of squirrels; here we have the first gradation from animals with their tails only slightly flattened, and from others, as Sir J. Richardson has remarked, with the posterior part of their bodies rather wide and with skin on the flanks rather full, to the so-called flying squirrels; and flying squirrels have their limbs and even the base of the tail united by a broad expanse of skin, which serves as a parachute and allows them to glide through

the air to an astonishing distance from tree to tree. We cannot doubt that each structure is of use to each kind of squirrel in its own country, by enabling it to escape birds or beasts of prey, or to collect food more quickly, or, as there is reason to believe, by lessening the danger from occasional falls. But it does not follow from this fact that the structure of each squirrel is the best that it is possible to conceive under all natural conditions. Let the climate and the vegetation change, let other competing rodents or new beasts of prey immigrate, or old ones become modified, and all analogy would lead us to believe that some at least of the squirrels would decrease in numbers or become exterminated, unless they also became modified and improved in structure in a corresponding manner. Therefore, I can see no difficulty, more especially under changing conditions of life, in the continued preservation of individuals with fuller and fuller flank-membranes, each modification being useful, each being propagated, until by the accumulated effect of this process of natural selection, a perfect so-called flying squirrel was produced."

"Now look at the Galeopithecus or flying lemur, which formerly falsely ranked amongst bats. It has an extremely wide flank-membrane, stretching from the corners of the jaw to the tail, and including the limbs and the elongated fingers: the flank-membrane is, also, furnished with an extensor muscle. Although no graduated links of structure, fitted for gliding through the air, now connect the Galeopithecus with the other Lemuridæ, yet I see no difficulty in supposing that such links formerly existed, and that each had been formed by the same steps as in the case of the less perfectly gliding squirrels; and that each grade of structure was useful to its possessor. Nor can I see any insuperable difficulty in further believing it possible that the membrane-connected fingers and forearm of the Galeopithecus might be greatly lengthened by natural selection; and this, as far as the organs of flight are concerned, would convert it into a bat. In bats which have the wing-membrane extended from the top of the shoulder to the tail, including the hind-legs, we perhaps see traces of an apparatus originally constructed for gliding through the air rather than for flight."

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PRACTICAL DISINFECTION

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HEALTH is not the monopoly of any group or class. It is the common heritage and therefore should be the common property of all. Many are diseased because of a lack of knowledge of the important facts relating to health, and one of the main purposes of these series of lectures is to give everyone the store of knowledge which the field of science possesses.

No one who has observed the progress of civilized countries along sanitary lines, can fail to have arrived at the conclusion, that changes for the better have taken place during the past number of years. Much of this is due to an enlightened public consciousness in all that concerns the well being of the everyday citizen. It is true that more could have been done; but if you realize that measures advancing the cause of public health are at first most frequently met with restraint, you will agree that caution and watchful waiting are the only available policies and these necessarily result in slower progress.

More work needs to be done in developing effective methods for the prevention of many of our diseases, and to rid environments of insanitary conditions. Additional research work must be done before all facts and factors involved will be fully understood, but there is still a greater need for a better and more complete application of the knowledge already available in the actual practice of known sanitary methods. May I emphasize the fact that education develops an enlightened public opinion. With this, greater progress can be made, resulting in a more favorable reaction in the health and happiness of everyone.

The belief that diseases are caused directly or indirectly by living micro-organisms, usually of plant origin (whence they are known as bacteria), but in some instances of animal origin (whence they are known as protozoa) is now securely established. Many members belonging to these groups of small living matter have also been

found to be the agents that are the offenders in the production of putrefaction and decay.

The composition of these micro-organisms is in many ways similar to the individual cells of our own bodies. Their presence on or in our bodies or about our surroundings is our own fault. We have no one to blame if we ignore them or actually invite them through insanitary measures.

Before considering methods of eradication, let us observe the conditions which are essential for the proper growth and development of bacteria.

First.—Proper nutrition.

Second.—Presence of moisture.

Third.—Proper temperature.

Fourth.—Presence of air and in few instances the absence of the direct supply of air or oxygen.

Fifth.—Absence of direct sunlight and retarding chemicals.

All five of these are necessary. The complete absence of any one of them will reduce the activity of practically all of the bacteria, commonly found producing diseases, putrefaction, etc.

Like all plants, bacteria require food. Carbon, hydrogen, nitrogen, oxygen and inorganic salts form the basis for their food supply. In order to flourish and build themselves up, they must obtain their carbon from the complex compounds, the proteins, carbo-hydrates and fats. In this respect, they closely resemble animal life. The bacteria are provided with suitable ferments or enzymes to digest these various organic combinations. These elaborate compounds are mainly found in animal and vegetable matter, which may be clean wholesome food or the component parts of dirt, filth, etc. Bacteria are therefore dependent upon the former or latter for their nourishment.

Moisture is indispensable to the growth of bacteria. This is taken up by the cell from the moisture in the surrounding medium, and is mainly used to dissolve the food material upon which bacteria thrive.

All bacteria require oxygen in some form in order to multiply and reproduce. Upon examination, we find that some bacteria are dependent upon the presence of free oxygen and air. They are known as Aerobes. Others require the non-presence of direct air or oxygen in order to multiply. They are known as Anaerobes.

Though they do not require direct air or oxygen for propagation, it is not to be supposed that the anaerobes are not dependent upon this element for proper development. They obtain the necessary oxygen indirectly by splitting up the various organic compounds, especially proteids and carbo-hydrates.

In addition to the previously mentioned requirements, a suitable temperature is necessary for the proper growth of bacteria. Each species has a minimum, a maximum and an optimum or most suitable and best temperature at which it will develop. There is a slight variance between the suitable temperature required by micro-organisms, but as a general rule, it may be said that in the case of the parasitic bacteria (micro-organisms developing on living matter), the temperature of the living host may be considered as best adapted for their growth. Saprophytic bacteria (bacteria living on dead matter), on the other hand, develop best at a temperature of ordinary room conditions.

The maximum temperature for the proper development of bacteria is, of course, apparent, inasmuch as high temperatures will weaken the ordinary forms of bacteria. You can also appreciate that below a certain temperature, bacteria will not reproduce. Freezing over an extended period of time will destroy many bacterial species, and most all degrees of cold will prevent the multiplication of bacteria. This accounts for the cold storage as applied in our various food industries, and the ice methods, employed in keeping cadavers in those sects in which embalming is not practiced.

Bacteria develop best in dark or in diffused daylight. The direct rays of the sun weaken the bacteria and finally, in most cases, kill them.

The absence of retarding chemicals will be more thoroughly explained later.

I think you will realize that personal uncleanliness and the insanitary conditions of our surroundings (whether it is dirty or contaminated utensils, filthy floors and furnishings, accumulated dust and dirt, dampness, absence of sunlight, poor ventilation or foul air, or a general lack of cleanliness and healthfulness of our surroundings), are perhaps the direct factors resulting in the increase or retention of these undesirable offending organisms. To limit the chances of the spread of the latter, we must get rid of their breeding places, prevent their development, and fortify such efforts already achieved by the proper use of destructive agents.

The question which everyone has asked himself or others at some time is: "What is the best method of ridding material or environments free of organisms?"

Haphazard, arbitrary procedures have given way to scientific and precise methods. It will be impossible to cover even a portion of this most interesting topic, due to the short space of time allotted. I will therefore confine this talk to a consideration of the methods that may be used to destroy bacteria in or about the home and its environments, leaving for a later consideration the destruction of bacteria in or on the body, etc.

There are a number of terms, which are used when referring to the processes of destroying or rendering disease-producing germs harmless. These kindred terms are here defined:

Sterilization means the destruction of living micro-organisms or their removal from materials. The term is used when referring to any method or procedure by which such end result may be accomplished. It is, however, used specifically or frequently limited to the destruction of bacteria by heat.

Disinfection is synonymous with the term sterilization; but it is employed mainly to designate that process where chemicals are used as the means of ridding environments free of bacteria.

Fumigation is also synonymous with the above terms, but applied only to those procedures in which a gaseous chemical or fumes generated from a chemical or drug are employed to obtain the desired end result.

To illustrate these terms: If we were to take some wearing apparel and boil it in water or place it under the influence of steam for the required length of time, it would be best to say—we are sterilizing the clothes. If, on the other hand, the material was placed in a solution of carbolic acid or other suitable chemical, one should say, we are disinfecting the clothes. But if the material was placed in a compartment where Formaldehyde Gas was being generated, then one should say the material is being fumigated.

The destruction or getting rid of organisms is brought about by a number of methods, which briefly mentioned are:

1. By the process of filtration.
2. By the aid of chemical agents.
3. By the use of heat.

Before entering into a consideration of the above-named methods, mention should be made of certain physical agents which exert a deleterious action upon bacteria, but which are either employed to a limited extent or not regarded by the layman as being methods of sterilization.

1. Light.

The direct rays of the sun act as powerful destructive agents for most all bacteria. The rays kill or render inert most of the commonly known bacteria in a comparatively short time. The period ranges from a few minutes to several hours, depending upon the type of organisms exposed and environmental conditions. Diffuse light will require a much longer period of time to obtain the same result. Unfortunately, some light is a variable quantity, being more or less dependent upon atmospheric and other conditions. It is frequently impossible to have materials or environments exposed directly to its actions. One, therefore, cannot solely depend upon it, but it should be employed as an adjunct to any other method that may be used.

2. Air.

"Plenty of Sunshine and Fresh Air" is the old maxim. The sterilizing quality of sunshine has been touched upon. The free circulation of pure air is very essential, inasmuch as atmospheric oxygen will dilute the bacterial content, will usually carry along the germicidal action of sunlight, and will favor drying, which in turn hastens the death of many organisms.

3. Cold.

Freezing temperatures check bacteria growth, and after a prolonged period of time, many of the organisms present finally die. Cold, recognized as a valuable and effective means of checking bacterial growth, is universally used by dealers in food products as a food preservative. In like manner, it is used by individuals in various professional pursuits with the same thought in mind.

The use of the previously mentioned methods is but limited, and they are at times either impracticable, inconvenient or unsatisfactory as procedures, which the housewife can depend upon to accomplish disinfection. One must therefore call upon the three practical

methods, which were mentioned previously. We can quickly scan over the process of filtration, as a method of sterilization, for this procedure has but a limited use. In the application of heat or chemical agents, one aims at the destruction of the organisms. When filtration is employed, however, the removal of bacteria is accomplished without necessarily destroying the latter. The action is entirely mechanical, and this method is generally employed in the biological laboratory only for the sterilizing of those liquids which are affected by heat or chemicals.

Sterilization by filtration, as used commercially or in the home, yields a product which is rarely, if ever, bacteria free. The filters, which some laymen use in their homes by attaching them to the water tap, or the sand filters, as employed in water filtration plants, remove some bacteria, but do not yield a sterile product, as is produced when bacteriological filtration is employed with scientific exactness.

The most widely used as well as most efficient agent for sterilizing material in the laboratory, home, etc., is heat. Heat may be used in many forms.

A. Direct flame or incineration.
B. Hot air or dry heat.
C. Moist heat.

The direct flame needs little, if any, explanation, for one can readily see that, if available, this is the best procedure for the sterilization and disposing of affected materials that are comparatively valueless. All sorts of materials, as paper sputum cups, gauze, cotton and paper soiled with discharges, infected clothing, books and other materials having little value, are easily destroyed by burning. Even the sterilization of refuse and defecated material in temporary camps can be sterilized by burning or igniting them in suitable trenches made in the ground.

In the laboratory the process of applying direct fire to materials is known as "flaming." An alcohol lamp, a bunsen burner, or other devices, which will give us a non-illuminous flame, is employed. Various equipment, which would not be affected by exposure for a short time to a direct flame, can be conveniently sterilized by this process. Inasmuch as most materials in the home are likely to be

affected by the high heat which is produced, other methods of sterilization are generally employed by the laity.

Dry heat or dry hot air is generally applied by means of what is known as a hot air sterilizer, which is very similar to the compartments found in the ordinary gas stoves or ovens. Articles or substances are placed in this sterilizer and allowed to remain at a temperature of three hundred degrees Fahrenheit for over an hour. This will generally kill all bacteria, but, as an efficient method, finds practical use only in the clinical or bacteriological laboratory, and is rarely, if at all, employed by the laity.

Dry heat kills bacteria due to the fact that the organisms are decomposed, or as we scientifically say, are oxidized. In the case of moist heat, the effects appear to be a direct action, either physical or chemical (coagulation and alteration upon the bacterial protein).

The action of boiling water for thirty minutes or longer will kill most bacteria, while even five or ten minutes boiling will so modify most bacteria that they will have lost their property of producing disease. This method can be used when it is desired to be assured that liquids and foodstuffs intended for human consumption are free of disease-producing micro-organisms. Water, milk, solid foodstuffs placed in water, and similar products can be boiled for at least ten minutes or preferably one-half hour. Many articles, such as dishes, glassware, rubber equipment, instruments, sheets, bed clothing, towels, other cloths and materials too valuable to be destroyed, can be and are sterilized by this method, because this is generally the most convenient and available agent.

Another method is to expose articles to be sterilized to direct steam, which attains the same temperature as that of the boiling water bath.

Subjecting steam under pressure by the use of suitable devices is a most efficient and ultimately most economical method of sterilizing many articles. Steam under pressure is the most powerful method of ridding material free of bacteria, but inasmuch as suitable compartments or plants are required for this purpose, to be operated only by experienced workers, this method can be but rarely employed by the laity. It is only extensively used in laboratories, hospitals, clinics, detention camps and by sanitarians in general.

Fumigation.

Fumigation has been defined in a previous chapter. This method of ridding materials and environments free of bacteria was extensively used in days gone by. As an efficient method for the destruction of various insects, fumigants that are efficient insecticides are being used more frequently; but as a bactericidal agent, gases are being used to a limited extent only.

The objections to bactericidal fumigants are many, and from the viewpoint of the laity, these objections are especially true, due to the fact that the average individual is not prepared to perform the correct technique properly. It is therefore impossible to place any reliance upon this measure of sterilization, when so conducted. I might mention in passing, however, that formaldehyde gas is the most efficient and most practical bactericidal fumigant, having little or no insecticidal properties. You will find that most of the boards of health have abandoned the procedure of formaldehyde fumigation. Though almost ten years have elapsed since the leading sanitarians have advised and have taken this step, they have found no cause to change their minds, or regret the action that has been taken. I cannot be too emphatic in stating that fumigation, as conducted by the laity, especially for the destruction of disease-producing germs, is a useless expenditure of money and a waste of time. It is even worse, it is a dangerous procedure, as it creates a false sense of security, with the result that the individuals do not do that which they really should. The environments and materials from which they thought they eliminated the disease-producing organisms become in reality a greater menace than they were before.

The laity is compelled to depend extensively upon the properties of disinfectants, inasmuch as the technique for their use is simple; they are most economical; and in the hands of laymen, they are more effective than the other methods that have been outlined.

A disinfectant frequently referred to as a "germicide" or "bactericide" is a chemical or a drug or a solution of these, that will destroy micro-organisms or render them harmless. Disinfectants may or may not act as insecticides, that is, kill insects. They may or may not necessarily be deodorants, that is, remove impure or obnoxious odors.

An antiseptic differs from a disinfectant in not killing the organisms present in a given substance, but merely stopping or preventing the further growth and development of these organisms.

A "bactericide," if diluted sufficiently, will only act as an antiseptic (*e. g.*, 5 per cent. solution carbolic acid is bactericidal, one-half per cent. solution is only an antiseptic).

Not all antiseptics can be concentrated sufficiently to act as bactericides, as, for instance, Benzoate of Soda, Boric Acid, Peroxide of Hydrogen are only antiseptics and never in themselves become bactericides. It is evident that the use of disinfectants in the prevention of decomposition or as an aid in general sanitary measures is a very large subject. You will also be able to observe shortly, that no one disinfectant can be regarded as the ideal one and to be employed in all cases.

To consider all of the disinfectants would require days of discussion. I will therefore attempt to cover merely the important characteristics to be considered during practical disinfection, and mention the most important disinfectants which may be employed, and are typical of the class of "General Disinfectants." At a future occasion I will attempt to bring to your attention the disinfectants that have more specialized and specific uses.

May I first bring to your attention a number of simple yet important regulations, which must be observed at all times, when using a chemical or a chemical solution, as a disinfectant.

Be Sure

1. That the chemical has been proven to be a disinfectant.
2. That the chemical will not be changed into an inert substance, when coming in contact with the material you are about to disinfect.
3. That a sufficient quantity of the disinfectant is used. (By merely throwing a drop of a diluted phenol solution in a sample of sputum does not say that the latter will be disinfected.)
4. That the germicidal agent will come in direct and intimate contact with all of the bacteria.

   (Floating a germicidal solution over a liquid to be rid of bacteria is not sufficient. It is necessary to shake the mixture thoroughly, so that the bacteria will be placed in direct contact with the disinfectant.)
5. That the disinfectant will remain in contact with the bacteria for a sufficient length of time to exert its action.

(Dipping contaminated clothing in a disinfectant solution for a few minutes and then removing the material will not kill all the bacteria. At least fifteen minutes or even a longer length of time is necessary, depending upon the chemical solution used.)

With very few exceptions, faulty disinfection and poor results can always be found to be due to carelessness by not considering one of the foregoing rules. There are other factors that influence the use of one chemical instead of another:

1. Low cost (compound solution of cresol is to be preferred to carbolic acid because it is cheaper and a more effective disinfectant).
2. Ready solubility or miscibility with water or commonly employed solvents. (Compound solution of cresol, containing 50 per cent. cresol is to be preferred to a mixture containing 75 per cent. cresol in kerosene, due to the fact that the latter is immiscible, while the former is miscible with water. A kerosene preparation of cresol will not kill bacteria in a mass, because it will not mix with the water on the material, where the micro-organisms are present.)
3. Should not be toxic to both man and animals, and should not bleach, tarnish or otherwise affect the furnishings in a household or material to be disinfected.
4. Temperature that can be used. Warm solutions of chemicals are more effective disinfectants than cold solutions.
5. A chemical having a great penetrating property and requiring but a short period of time for disinfection is to be preferred.
6. A stable compound both under ordinary conditions, or when employed as a disinfectant.
7. Should not possess a disagreeable odor.

In this country, an act, known as the Insecticide Act of 1910, was adopted for the purpose of preventing the manufacture and sale of adulterated or misbranded insecticides and fungicides. The Insecticide and Fungicide Board of the Department of Agriculture has been vested with the power of regulating the traffic in disinfectants and germicides, and it may be pointed out here, that they have within

recent years ruled that a disinfectant insoluble or immiscible with water, or one that loses its strength and germicidal efficiency, when coming in contact with organic matter, should not be termed a disinfectant for general use.

The actual changes taking place when disinfectants are used for the destruction of bacteria are not clearly understood as yet. Some seem to act by penetrating the cell wall, and enter the cell proper and there exert a toxic action (Ex. Dilute Alcohol). Others act as dehydrating agents, withdraw moisture from the individual cells, and the latter subsequently die (Ex. Absolute Alcohol). In some instances, there is a quick coagulation of the cell protoplasm or the formation of an insoluble and impenetrable substance, which prevents nourishment from gaining entrances, and the bacteria eventually die (Ex. Formaldehyde). Again there are those chemicals that, by rapid oxidation, cause a destruction of the bacterial cell (Ex. Peroxide of Hydrogen, Permanganate of Potash, etc.).

Chemical germicides may be used dry (as iodoform), in solution (Bichloride 1:1000), or in a gaseous state (formaldehyde). The number of chemical agents having destructive action on bacteria is very large. Each possesses its own particular usefulness, and due to such individual characteristics, each is more or less ideal in its own field.

I will first consider the disinfectants, which have been extensively exploited, or otherwise recommended by laymen to laymen, and which either have a limited use or are dangerous substances to include with the more important commonly used disinfectants which will be discussed lastly.

Bichloride of Mercury.

Bichloride of Mercury, known also as Corrosive Sublimate and Mercuric Chloride, is an extremely poisonous chemical, the sale of which is generally regulated by law. Though one of the most powerful disinfectants known, and employed extensively for medical and surgical applications, it has but a limited use as a general disinfectant in the home, due to the following disadvantages it possesses:

1. Highly poisonous. Cannot be used in containers used for foodstuffs, etc.
2. It fixes stain in soiled fabrics.

3. It is precipitated by soap, and sulphur compounds.
4. It coagulates albumen and accordingly cannot be used for the disinfection of feces, sputum, pus or any other material containing protein. An insoluble coagulum of albuminate of mercury is formed, which has little or no disinfecting properties, and which prevents further penetration of any excess of Bichloride of Mercury that may still be present.
5. It is injurious to metals. Therefore never use Bichloride of Mercury for the disinfecting of metallic instruments.

This disinfectant is usually sold in the form of tablets, which, when dissolved in a stated amount of water, will yield a solution which is bactericidal. The only convenient use of this solution as a household disinfectant is for the disinfection of contaminated clothing, bed linens and similar materials in a sick room by keeping the latter therein for one hour and then washing and laundering.

Formaldehyde.

Formaldehyde is marketed in two forms. One which is sold in compressed form as a powder is used as "Paraform" or "Solid Formaldehyde," a term which is erroneously applied. A solution of Formaldehyde gas in water, sold under the name of "Formalin" or "Solution of Formaldehyde," is more extensively employed, either in its liquid state, or as a medium from which the gas may be liberated.

Gaseous Formaldehyde, obtained by heating solid Formaldehyde or from the solution in water, is the most efficient, as well as the most practical bactericidal fumigant, and should be the only gas to be employed when the object of the fumigation is to get rid of bacteria. This vapor, however, has no insecticidal value. Inasmuch as I have expressed an opinion that fumigation generally in the hands of most laymen yields unsatisfactory results, I will not consider at this time the exact technique which one should employ during Formaldehyde Gas fumigation. The liquid, which contains from 37 to 40 per cent. Formaldehyde gas in water, is in itself a reliable disinfectant, when employed in a dilution of one or two volumes of solution in nineteen volumes of water, using an exposure of one hour. This solution has the advantages over bichloride, in that it is not highly poisonous, non-corrosive, non-injurious to even

delicate fabrics, not affected as readily by organic matter, and in addition is a very efficient deodorant. I personally have never recommended Formaldehyde Solution to any great extent as a general disinfectant to be employed by the layman, unless the disinfection is to be done in an environment and at a time where humans will not be found constantly. The liquid has a pungent odor, and the vapors which are liberated, because the gas is volatile, are irritating to the mucous membrane of the eyes, nose and throat. Also, if there is sufficient heat about, there may be enough of the gas liberated, leaving an amount of disinfectant in the material that is being treated which may not necessarily kill bacteria in the given hour time, which is generally specified.

Chlorine and the Hypochlorites.

There are many commercial preparations marketed which depend upon *Chlorine* for their bactericidal efficiency. Many attempts have been made through advertising campaigns to introduce and popularize these chlorine products as general disinfectants. For such general use, the well-known liquids—Labarraque's Solution or Javelle Water, and the powder Chlorinated Lime, which can be bought in the corner store, will be found as efficient as any of the advertised chlorine products. The use of chlorine preparations for general disinfection is, however, restricted. They all leave an objectionable odor, are powerful bleaching agents, corrode metals, are easily decomposed when coming in contact with organic matter, quickly lose their strength if left uncovered, and a fact that is perhaps very important but not mentioned by the manufacturer, the chlorine preparations will not destroy the tubercle bacillus.

As a disinfectant and deodorant, for the chlorine preparations are powerful deodorants, the application of the latter is limited to the treatment of refuse, sick room discharges, manure, etc., outside of the home, or around privies, stables, barnyards or in environments that may not be affected by the odor and the other undesirable features. A satisfactory dilution is to use about five ounces of the above-mentioned product in each gallon of water.

In preparing the latter dilution, if the powder is employed, best results may be obtained by first rubbing up well the chloride of lime with a little water, as in making a flour paste, and finally adding enough water to the desired volume. In applying this solution to

sick room discharges, etc., it would be advisable to add at least volume for volume to the discharges, etc., and then add a little excess amount, so as to allow for the loss of chlorine decomposed by the organic matter. The only place where the writer would feel free to recommend either a solution of Chlorinated Lime or any of the other Chlorine compounds, as a desirable disinfectant, in the home, in preference to other disinfectants, would be in the cleaning and disinfection of empty ice-boxes, refrigerators, vats, casts, etc., providing that these would be lastly washed with hot water or steamed out, so as to get rid of any traces of Chlorine that may remain.

Carbolic Acid.

The term carbolic acid has unfortunately been employed rather loosely by the laymen, and many preparations that are closely related have been at times erroneously designated under this heading.

Carbolic acid, or phenol, as it is more properly termed scientifically, was discovered in 1834, and was thought to be the same as Wood Creosote, then regarded as a very valuable disinfectant, especially for the preservation of timber. This was soon found to be incorrect. Creosote, though an important disinfectant, is insoluble in water, coagulates albumen, and as such is rarely employed, today, as a general disinfectant.

Phenol in its pure state is a solid at ordinary temperatures, occurring in large masses of long white needle-shaped crystals, which assume a reddish tint upon aging. By adding one part of water to each nine parts of crystal, liquid carbolic acid or liquid phenol is the result. This is what is usually obtained in the drug store, when carbolic acid is ordered. A 5 per cent. solution of the latter is a very satisfactory general disinfectant, having a wide range of usefulness. An equal volume added to urine, feces, sputum and other excretions, mixed thoroughly, and allowed to stand for at least one hour before final disposal, will insure the destruction of bacteria, that may cause disease. In a solution of that strength or even one-half the strength mentioned, floors, walls, etc., may be mopped. Soiled linen, bed clothes, fabrics, metallic instruments, etc., may be immersed in such solution for one hour to insure disinfection.

It should be remembered that a solution of Carbolic Acid is highly poisonous, and care should be observed in keeping it about the home. Other than this, phenol has been found inefficient in its

attempt to destroy the causative agents of Anthrax, Tetanus and those diseases in which the etiological factors are highly resistant. It is also very expensive and for the previous stated reasons is not recommended as highly as the so-called coal tar disinfectants that are to be mentioned later.

Crude Carbolic Acid.

In certain quarters, the laity seems to demand the so-called Black Carbolic Acid in preference to the White Carbolic Acid, which was previously discussed. This substance is not carbolic acid, but a mixture of chemicals, closely related to pure carbolic acid, together with other substances referred to as the Coal Tar Oils. It is not as efficient as phenol, leaves a disagreeable odor and an objectionable residue. When diluted, it is only efficient if a 5 per cent. solution is mixed together, preferably with a little heat, with an equal volume of a 5 per cent. soft soap solution. Such an emulsion is practically similar to the emulsified coal tar disinfectants, which can be bought on the market in a concentrated form and a purer condition.

Coal Tar Emulsions.

In days gone by, bituminous coal was heated by a special process (known as destructive distillation) so as to obtain the residue which, known as coke, a fine form of carbon, was to be employed in the manufacture of steel. The other substances, known as by-products, produced during such distillation, were thrown away. This comprised especially a liquid which possessed a disagreeable odor and a characteristic black tar appearance. Today, the latter rather than the residue, is mainly sought in the treatment of bituminous coal. By special processes of heating, known scientifically as fractional distillation, many different liquids are obtained from the coal tar liquid. Many of these are closely related to carbolic acid or phenol, and though they possess specific names, as cresol, etc., they are frequently grouped under a general heading, known as Phenols. May I impress upon you that the so-called phenols (general term) differ in many respects from Carbolic acid or phenol (specific term). This is almost similar to the term Alcohol, as employed by the chemist. The latter term is used specifically, when referring to grain or ethyl alcohol, but also is employed in a gen-

eral sense, when referring to a group of closely related chemical substances, and thus we have wood or methyl alcohol, glycerine or glyceryl alcohol, etc.

With few exceptions, the active phenols or disinfectants in this coal tar substance are all liquids, and are but slightly soluble in water. On this account, they usually require a solvent or other carrier to bring them into a condition so as to make them soluble, and thus exert their activity more readily. Soap (both hard and soft) is mainly employed as the vehicle for the so-called coal tar oils. It acts as an efficient emulsifier of these products, forming such combinations, which are readily soluble in or miscible with water. The end preparation is generally referred to as an emulsified coal tar disinfectant. Because of the presence of the soap, they possess a cleansing, as well as the additional germicidal property.

As a class, these coal tar disinfectants are active germicidal agents and deodorants, cost less than most of the other disinfectants, and where the slight odor is not objectionable, they are to be preferred to any of the other disinfectants herein mentioned. In the dilutions commonly employed, they are non-toxic, non-irritating, non-corrosive and do not have their efficiency lowered by the presence of albuminous or other organic matter.

Compound Solution of Cresol (U. S. P.).

Compound solution of Cresol (U. S. P.) (similar to Lysol, etc.), is representative of the so-called soluble coal tar disinfectants, and made with soft soap as a base. Creolin is a type of the emulsifiable coal tar preparations, which form a milky suspension, when mixed with water. There apparently seems to be no material difference as far as the bactericidal efficiency is concerned between these two types, though at one time it was thought that preparations of the latter type were more efficient.

The coal tar disinfectants differ among themselves as far as their relative germicidal efficiency is concerned. This is because of the different kinds of oils, and the different methods of preparing these products, so as to obtain a substance soluble in or miscible with water. It is almost impossible to determine the exact nature of phenols present in such an endless variety. And even if such procedures were at all possible, the germicidal value of the particular preparation would still be unknown. Many attempts have therefore

been made by bacteriologic methods to determine the germicidal value of disinfectants, and develop a possible means of standardization. Numerous procedures and methods of technique have been introduced, but it is evident that none are recognized except "The Phenol Co-efficient Tests."

The bactericidal value of Phenol or Carbolic Acid, recognized as an efficient germicide, is taken as unity. The germicidal value of any other chemical is determined by actual comparison with phenol. Both are tested under identical conditions, using the TYPHOID BACILLUS as the test organism. By observing the dilutions of the samples which are as efficient as given dilutions of phenol, a ratio of the germicidal power of the disinfectant compared to the germicidal power of phenol can be obtained (especially so, inasmuch as both disinfectants were tested under identical conditions). The ratio is expressed in what is known as the "Phenol Co-efficient." This is a numerical figure, which indicates how many times more or in some cases less is the bactericidal efficiency of a particular disinfectant as compared with phenol. From the known phenol co-efficient, one can quickly determine the dilution of a disinfectant, which still will retain the equal germicidal value as a stated phenol dilution.

The United States Government does not compel the labeling of a disinfectant with its phenol co-efficient, but through the fungicide and insecticide board, they do compel a manufacturer to market his disinfectants to be of the particular co-efficiency, as shown on their labels, if a stated phenol co-efficient is given. There are, however, certain states in the Union that compel manufacturers to state the phenol co-efficient of their disinfectants on the label before they can be sold. Maryland was the first state to adopt such a law.

At first thought, one can easily see the advantages in a phenol co-efficient. A figure is at once available which will show the comparative strengths of the many disinfectants. But the tests are after all only relative, and it is a known fact that the conditions imposed upon the laboratory tests are not identical with the action of the disinfectant in practice. As has been shown by many workers, the phenol co-efficient is almost worthless as a comparative figure to determine the disinfecting value of chemicals of a different nature (*i. e.,* different chemical composition).

In a modified way, this test is somewhat satisfactory as a figure for comparison of the coal tar disinfectants. Even here some dis-

crepancies exist. I feel that the phenol co-efficient should be used for coal tar products only, until such time that better methods of determining relative values of disinfectants will be devised.

As a safe dilution of all these coal tar emulsifiable disinfectants, two ounces of the product to each gallon of water will be usually of sufficient strength to give a dilution which will be an active germicidal agent. It can be used to advantage in the disinfection of floors, walls, metals, linens, clothing, discharges, etc., and if the slight characteristic coal tar odor is not objectionable, its use can be extended to disinfect almost anything, except foodstuffs. It is my personal feeling that the slight characteristic odor is really desirable and not objectionable, for one can thus quickly tell that disinfection was conducted in a particular environment; and may we be frank to also admit that the psychological effect is at times to be desired.

You and your dear ones are frequently dependent upon each other for your health and protection against disease. If the facts related to you this evening were generally considered, appreciated and correctly applied, you and the community at large would profit thereby. Intelligent thought, greater interest and a closer intimacy with this important topic will be found to be worth while, the end result yielding an assurance that close attention to little things is rewarded with notable returns.

WHY SOAP?

By E. Fullerton Cook, Ph. M.

SOAP seems to occupy a very humble place in the affairs of the average home yet so important is its service that the health of a nation may almost be gauged by the amount of soap used.

It is a factor, too, in the comfort of the people. It is stated that the absence of soap was the deprivation most felt by those countries where the demands of the World War created a shortage in raw material.

But "Why Soap"? Probably this question can be answered by the soap maker who should know why soap is used. The widely flung claims of national and international advertisers tell one side of the story. They take for granted that the use of soap is universal, they know it to be a modern necessity, they vie with each other to perfect their product and offer the greatest value.

The current magazines reveal several of the uses for soap. For instance, full pages are devoted to telling the virtues of well-known laundry brands. One "Loosens the dirt you used to rub away," another "Won't redden the hands," a third "Makes washday easier," and is "gentle to clothes," still another "makes housework shorter and easier." Time saved, less work, better results—the appeal is strong!

But after all it is largely *how* to use soap that counts. Several of the larger producers of laundry soap conduct research laboratories to learn how to use soap for the best results and their advice should reach every household.

A second set of advertisements cover soaps for facial, hand and bath use and the chief appeal is for greater beauty. "Her beauty laughs at years," "Simple care triumphs over beauty's enemies," "The prettiest girl in her set," "A skin you love to touch," are some of the familiar and catchy phrases. One soap maker tells of "matchless fragrance," another of "assured health" through the removal of germs.

A third group of advertisers talk of shampoos to "cleanse and gently stimulate the scalp," and to produce "youthful and sparkling hair."

To men the shaving soap manufacturers make their varied appeals, the most potent one being "instantly softens the toughest

beard." Another type of soap is for the hands of the machinist or perhaps the amateur or emergency auto mechanic, and so the common applications and needs for soap are emphasized by every publicity medium.

But there are a hundred other reasons "why soap." In the textile trade it is extensively employed in the conditioning of wool and cloth, in surgery it serves as an agent in the preparation of an aseptic field for operation. It also becomes the base for liniments, as in "chloroform liniment," or a dressing for burns as in "Carron Oil." A certain type of soap is the main constituent in plasters and another form renders powerful coal-tar germicides miscible and usable, producing preparations of the "Lysol" type. Soap may also act as the combining medium between oil and water forming emulsions, as in "Almond cream," or make possible valuable lubricants when combined with petroleum oils.

Another type of soap becomes the solidifying ingredient in the well-known glycerin suppositories and in "solidified alcohol" or "canned heat." In another combination it is the chief ingredient in "vanishing cream."

After this array of facts need the question be asked, "Why soap"? The actual daily needs of our civilization demand it.

It has remained, however, for our century to develop manufacturing processes which bring this commodity within the reach of all.

The origin of soap is hidden in the unwritten history of early mankind. What is usually known as "soap," the washing kind, was, according to tradition, first brought to Rome from the north countries. One may readily imagine a crudely formed limestone fireplace, a wood fire, and the cooking of a stag or boar. The next step would naturally be the use of ashes to clean the kettle.

Here were all the elements of soap making. The wood ashes and lime supplied the lye, ready to saponify the fat. The product was soap. True this crude product was far removed from our modern soap but such might have been its discovery and even if accidental, we are deeply indebted to the one who first observed the result and handed on the information.

The upward rise of man has necessarily been slow. Countless ages have passed in advancing the first few steps. Between the crude discoveries in science of centuries past and the perfected products

of today lie the mysteries which distinguish man from the beast. It is that upward urge within the human race, that determination to improve, that hunger for knowledge, which is the ultimate hope of the world.

The Hebrew word "borith," in Jeremiah II, 22, translated "sope" and also the word "nether" translated, "fullers' sope," in Malachi III, 2, are both supposed to refer to some form of lye, not what is now called "soap."

Aristophanes and Plato (B. C. 400) both refer to the use of lye, but not to soap. The earliest known reference to a soap of the modern type seems to be by Pliny, who died during the eruption of Vesuvius, 79 A. D. He says with reference to the treating of scrofulous sores, "Soap too is very useful for this purpose. This is an invention of the Gauls for giving a red color to the hair. It is made from tallow and ashes, the best from beechwood ashes and goats' tallow. There are two kinds, solid and liquid. Both of these are used by the Germans, by the men in particular, more than the women."

It is said that during the excavation of Pompeii a complete soap factory, and soap in perfect condition were discovered.

Apparently, however, at that time soap was not used for cleansing and there is no evidence that it was employed for that purpose at any of the ancient Roman baths.

The first writer to mention soap as a cleanser was that very remarkable man, Claudius Galen, a renowned Roman physician born A. D. 130. He suggested a soap made from fat and lye which softens and removes dirt.

Early people had long used certain plants to assist in cleansing, presumably those containing saponin, such as soap bark, and the cleansing properties of "fullers' earth" have also been long known.

The physicians of two thousand years ago were also familiar with medicinal products which were soaps chemically. One of these was made by shaking oil with quicklime. This product was similar to one official in our modern Pharmacopœias, known as "Lime Liniment" and already referred to as "Carron Oil."

The making of washing soaps was for many years largely a domestic practice. As has already been implied, fats are essential to soap making and that used in the crude household soap was chiefly the oil drippings or "fryings" from cooking. Lye is also a necessary

ingredient for soap and for centuries its only source was wood ashes. This was crudely separated by "leaching," in which a so-called "lye-hopper" was used (Fig. 1), the ashes being slowly percolated by water to dissolve out the mixture of crude potassium carbonate and hydroxide.

For two hundred years soaps have been made in Europe for general sale, especially in the countries bordering the Mediterranean where an abundance of olive oil was available and today the terms "Castile" or "Marseilles" soap still implies the type of soap made in Spain or in French cities.

The making of soap was dependent upon securing sufficient soda or potash. For many centuries the latter was available only from wood ashes and while some soda may have come from deposits found in the coast countries of Asia or Africa, most of it had to be secured from the burning of sea plants.

Two developments occurring at the beginning of the nineteenth century changed the situation completely and made possible the development of the modern soap industry. Chevreul announced the result of his researches into the constitution of oils and fats, showing them to be combinations of fatty acids with glycerin and Leblanc discovered a method for making "soda" from salt, that is, sodium carbonate from sodium chloride. Like so many pioneers Leblanc did not live to have the value of his discovery appreciated. His early production of soda ash on a commercial scale in a factory erected at St. Denis, near Paris, under the support of the Duke of Orleans, was interrupted by the dark days of the French Revolution. The Duke of Orleans was guillotined, the factory confiscated and Leblanc forced to reveal his process to the State. Though his factory was returned in 1800, Leblanc was unable to secure financial help and in 1806, in poverty and despair, he took his own life. In 1824 James Muspratt, in England, undertook the commercial production of soda ash by the Leblanc process and with great success, the process proving to be of untold benefit to the world, especially as soda ash is also an essential ingredient in glass manufacture.

The classical investigation of the chemistry of oils by Chevreul, and the cheap production of soda lye marked the beginning of the modern soap industry. Increased sources of raw material have also been developed and recently the hydrogenation of fats has been one of the factors in producing cheaper soaps of good quality. By this

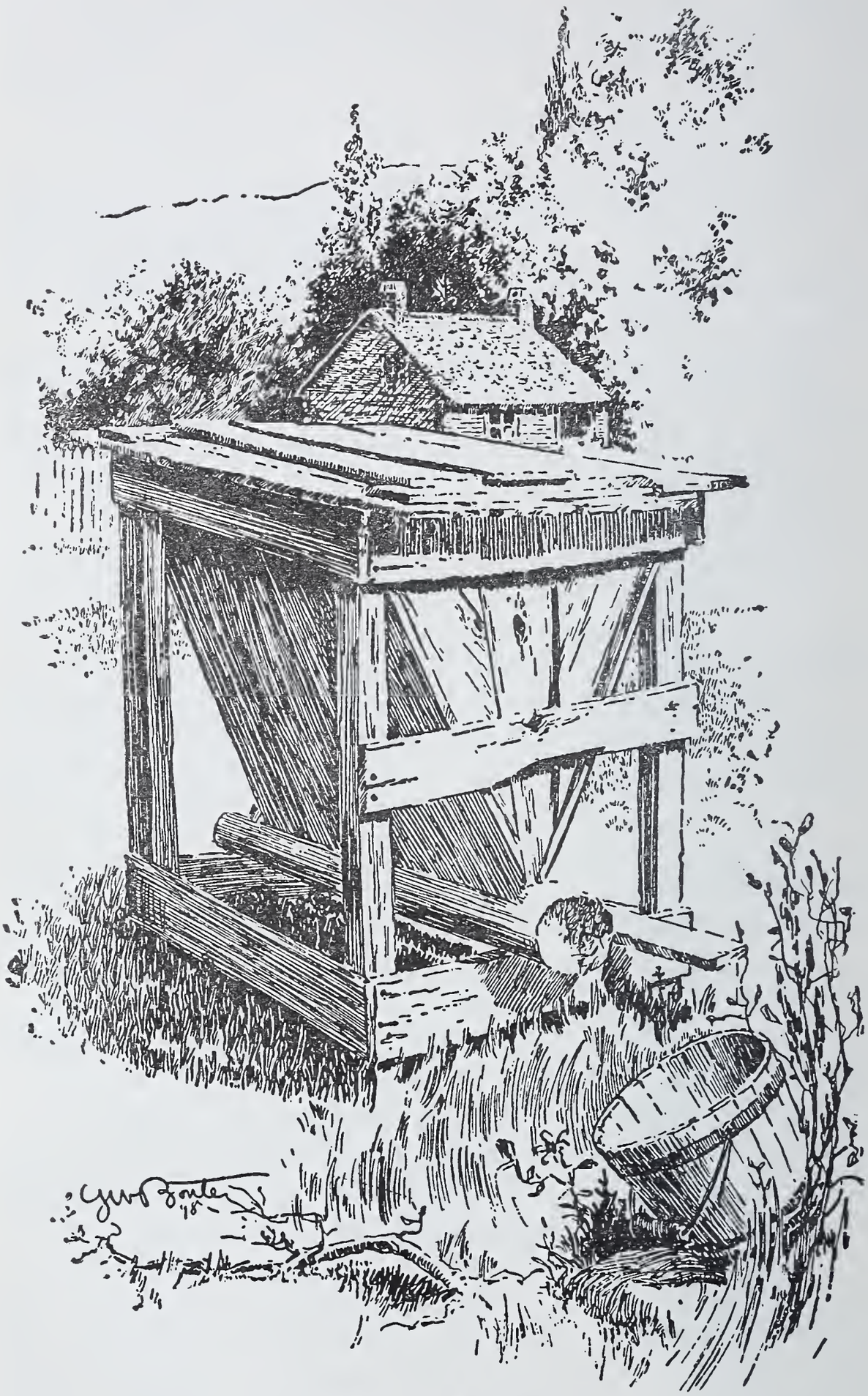


Fig. 1—Lye Hopper.

From Modern Soaps, Candles and Glycerin—L. L. Lamborn (D. Van Nostrand Co., N. Y.).

process odorous fish oils and many thin oils of the olein type are changed to stearins and made more fit for soap making. Another important result of understanding the chemistry of soaps and the development of modern methods and machinery has been the saving of the by-product glycerin, which for many years was turned into the sewer with the "spent lye."

This valuable triatomic alcohol is extensively employed as a solvent and preservative in pharmaceutical preparations and, at this time, is of special interest and advantage in replacing alcohol, because of its comparative cheapness, non-intoxicating character and freedom from government regulation and tax.

Glycerin is also of great economic value as an essential ingredient in the production of nitroglycerin from which dynamite is made. In peace times this commodity is invaluable in mining operations and in time of war becomes an important high explosive.

An element entering the economic question of soap production of today is the use for food of many of the oils and fats formerly only suitable for soap or candle making. This applies to the oils from the olive, peanut, cotton-seed and corn and also to cocoanut and tallow, the latter finding a place in butter substitutes.

The fats available for soap making today are from the sources just named in part but mostly the inferior grades, unsuited for foods, but other substances are also available and the soap maker is largely governed by the market price as to which ones he selects, many of them being interchangeable in soap production.

Other oils have extensive commercial uses as linseed oil in paints and castor oil as a medicine and lubricant so that they are not generally available for soaps.

But something should be said of the chemistry of fatty substances as demonstrated by Chevreul that there may be a better understanding of the problem. All neutral fats of animal or vegetable origin consist of glycerin or glyceride combinations with fatty acids. The two most important of these acids are oleic, which is liquid at ordinary temperatures, and stearic, which is a solid. As might be supposed glyceryl oleate represents the chief constituent of many fluid oils while tallow is mostly glyceryl stearate. The difference chemically between these two acids is represented by two additional hydrogen atoms in the stearic, and this explains why the new hydrogenation process, whereby hydrogen is added to the mole-

cule, through the aid of a catalytic agent, changes the oleins and other higher fatty acids to stearins.

Certain oils contain related but slightly different and distinctive fatty acids, such as palmic acid from palm oil, ricinic acid from castor oil, caproic acid from cocoanut oil, etc. Each of these acids has distinctive qualities which give different characteristics to soaps made from them.

In the saponification process the glyceride is replaced by the base, a salt being formed such as potassium or sodium oleate or stearate or palmitate, etc., and glycerin is liberated. A typical reaction is as follows: $C_2H_5(C_{18}H_{33}O_2)_3 + 3NaOH = C_2H_5(OH)_3 + 3NaC_{18}H_{33}O_2$.

The quality of the soap in a measure depends upon the completeness of the saponification and the care taken to produce a neutral or almost neutral soap.

For certain purposes, such as for exceptional detergent or germicidal value, as in "soft soap," to be used for cleansing the hands of a surgeon and in preparing an area for a surgical operation, a slight excess of alkali is desirable, but for toilet purposes and for the laundry the neutrality of the soap is essential. A few soaps are superfatter, that is, contain an excess of fat but these are only used for special purposes, such as to remove an excess of machine oil or some such form of dirt.

The kind of alkali used also has an important influence upon the character of the soap. Potash produces soaps of a soft consistence, and until recently was considered necessary for their production. It has been shown, however, that it may be replaced in part at least by soda without seriously modifying the consistence of the finished product. The home-made soaps from potash lye obtained from wood ashes produced a semi-fluid mass, slimy and slippery, which was not very satisfactory to keep or to use.

Soda in the form of the hydroxide, chemically NaOH, produces the so-called hard soaps, whether the fatty acid be liquid or solid, although the consistence of the latter increases or decreases in proportion to the consistence of the finished soap.

Another characteristic of the fatty acid influences the solubilities of soaps and thus has a bearing upon their adaptability: All soaps except those made from cocoanut oil are insoluble in salt (sodium chloride) solutions and therefore only cocoanut oil or chiefly

cocoanut oil must form the basis for what is known as "marine soap" to be used with sea water. This quality of soaps is taken advantage of in their manufacture to separate the glycerin, salt being added to the saponified mixture, causing it to rise to the top of the soap-boiling kettles (see Fig. 2) in more or less granular form, leaving the glycerin, "spent lye" and salt solution at the bottom to be drawn off and treated for the glycerin. The stage of the process is known as "graining." When the glycerin has been removed the separated soap is again heated and water added to restore a uniform consistence and this warm mixture is then drawn off into mixers, known technically

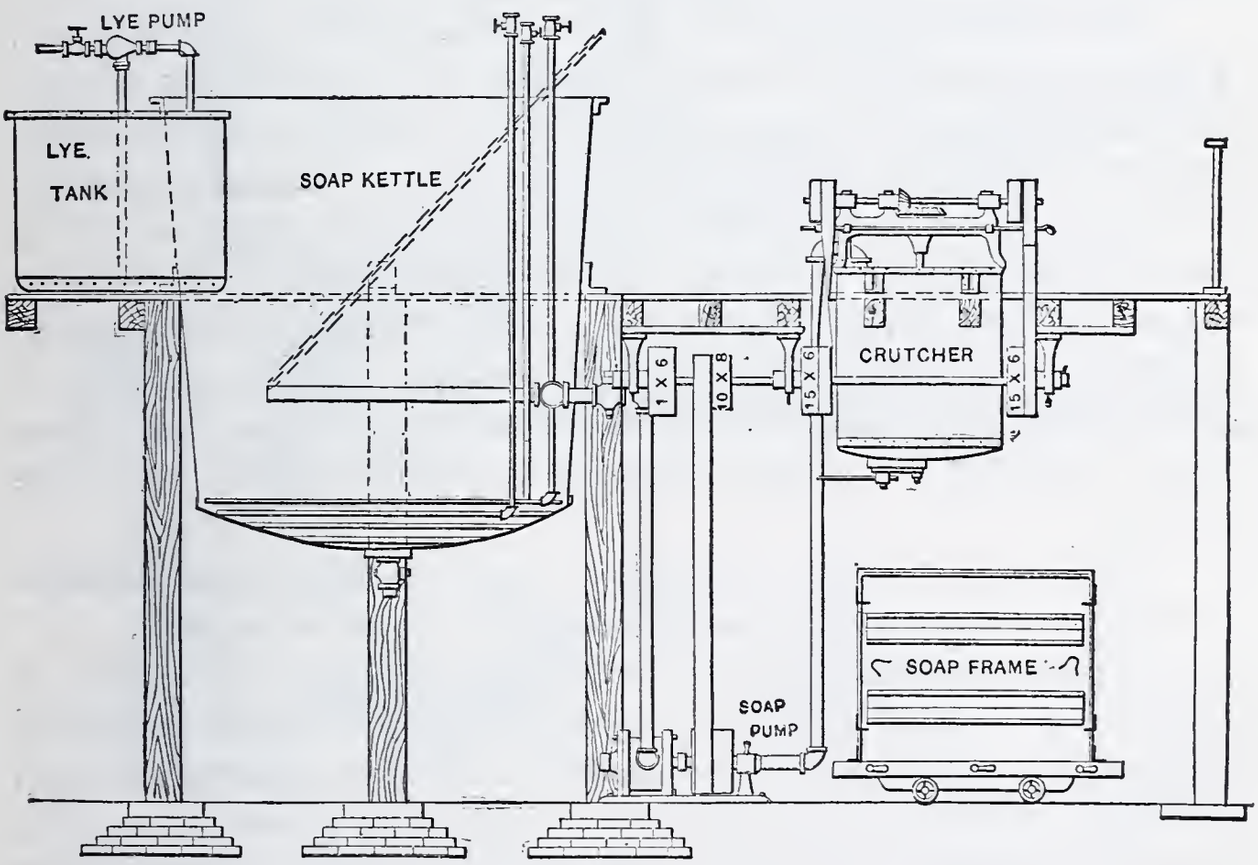


Fig. 2.

From Modern Soaps, Candles and Glycerin—L. L. Lamborn (D. Van Nostrand Co., N. Y.).

as "crutchers" (see Fig. 2), where, if the soap is a cheap laundry or washing soap, an inexpensive perfume may be incorporated, and a better consistence secured by actively stirring before the soap is run into "frames" to cool. If the soap is to be a "floating" soap, the "crutching" or beating is continued until sufficient air has been worked into the cooling mass to make the specific gravity less than that of water.

A "floating soap," therefore, means less soap and thousands of minute air spaces throughout the cake, which tend to increase its solubility and wasting qualities.

The "frame" (see Fig. 2) into which the soap is run to cool usually consists of an iron or steel box about 4½ feet long, 15 inches wide and 4 feet deep, mounted on wheels. The sides and ends are removable and each frame holds about 1000 pounds of soap. When the soap in the frame has cooled sufficiently the sides are removed and in due time the mass of soap is cut into slabs by forcing it against piano wires fitted to a frame, and these slabs in turn are cut in the same manner into bars weighing about three pounds each. In the cheaper laundry soaps these bars are further cut into cakes, and the cakes roughly stamped by a press, before being wrapped and boxed.

Much laundry soap is now being sold in powder and flake form. This not only enables the user to regulate the exact amount of soap used but also provides quick solution and is admirably adapted to the modern domestic or laundry washing machines. In the production of chip soap it is not necessary to run the warm fluid soaps into frames to cool as the crutched soap, while still fluid, is run between a series of cooled steel rollers and the thin film which dries on the rollers is mechanically scraped off at one stage of the process. It then drops to a movable belt and is carried into a warm closet, from which it emerges dry enough to market as "flake" or "chip" soap (see Fig. 3).

For the production of powdered soap the flakes must be more thoroughly dried and are then powdered in the usual manner.

It must be evident to all who know something of the nature of soap that an important factor in its actual value is the percentage of water it contains. Not only does this control the amount of soap available, but when large amounts of water are present a soap in cake form rapidly disintegrates when used and fails to give adequate service.

It may be startling information to some to know that often as much as 80 per cent. of laundry soap in cakes is represented by water. In flakes the water must be greatly reduced and is not often above 5 per cent. This is another reason for the preference of chip or flake soap over other forms, for laundry purposes.

Washing powders, on the other hand, are usually mixtures, rarely containing more than 20 per cent. of soap and often less. In addition to the soap they usually contain from 25 to 30 per cent. of "soda ash" (sodium carbonate), the remainder being water. This combination of soap and "soda ash" is particularly efficient in the

washing of clothes and, even if pure chip soap is used, the experts who conduct experiments in laundry methods advise the addition of soda ash to the first water.

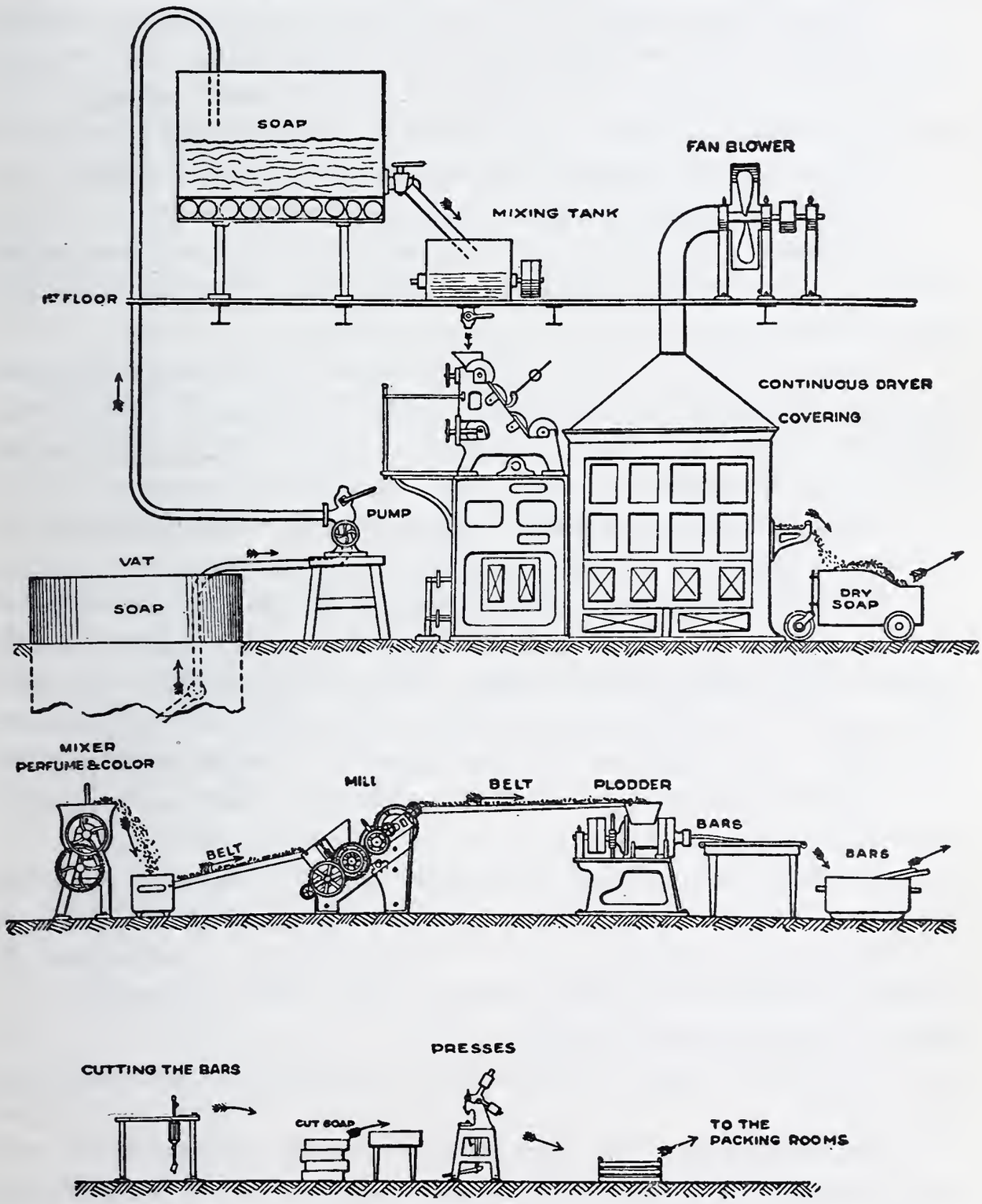


Fig. 3.

From Modern Soaps, Candles and Glycerin—L. L. Lamborn (D. Van Nostrand Co., N. Y.).

To produce the higher grade toilet or medicinal soaps the bars cut from the frames are reduced to chips by a chipping machine or scraped directly from the roller (see Fig. 3). These are further dried and then "milled" (see Fig. 3) by passing them repeatedly

through heavy rollers without heat, until a uniform mass results. During this process the coloring matter, if any, is incorporated and also the desired perfume or medicating ingredients.

This soft mass is then forced under heavy pressure into bars of the shape and size best suited to form the desired cake, the machine being called a "plodder" (see Fig. 3). These bars, while yet soft from the milling, are then cut into cake size and stamped into tablets.

The chief raw materials from which soaps are made are:

Bone Fat.—Extracted from bones boiling with water.

Cocoanut Oil.—From the cocoanut fruit, sometimes called "Copra." The chief commercial varieties are "Cochin," "Ceylon," and "pressed oil."

Palm Kernel Oil.—The oil pressed from the kernels of the palm fruit is obtained from the West Coast of Africa and from South America. The fruit from the same tree yields from the soft outer pericarp an oil known as

Palm Oil.—This is reddish brown in color and the red color persists in the finished soap unless bleached.

Olive Oil.—This oil produces the soap known as "Castile" and is mild and neutral and especially adapted to sensitive skins, and is almost universally used for babies. Such soap constitutes the official soap of the Pharmacopœia and is made from the cold pressed oil. Many other soaps are now being sold as "Castile soap," so that to obtain the original it is becoming necessary to ask for "Olive Oil Castile Soap."

Another grade of olive oil is also available, obtained from the residue after cold pressing and consists of skins, seeds, and pulp. It is obtained by extracting the oil with solvents. It is known as "olive oil foots" and is dark green in color. It is only suitable for making cheap household soaps.

Peanut oil is much like olive oil, but is not generally available in this country.

Cottonseed Oil.—This was formerly a waste product in the cotton industry, but is now extracted and has become not only an important soap stock, but when refined is largely sold as "sweet oil" and "salad oil" as a food.

Corn or Maize Oil.—In the preparation of starch from corn it is necessary to remove the soft oily tip of the grain of corn, known as the hilum, and from this an oil is pressed which is excellent as a soap stock and also as a food oil.

Soya Bean Oil.—This oil is largely imported from Japan and Far Eastern sources, and when available is a satisfactory soap stock.

Linseed Oil.—The importance of this oil in the paint industry lessens its use in soap making, but it produces an especially fine quality of soft soap, which has a less tendency to "fig," that is, separate crystalline masses of oleates than when made from other oils.

Castor Oil.—Other uses and the price restrict this oil in general soap making., but it is of special value in the making of transparent soaps and also in the production of a variety of hard soap for surgical purposes, which it is claimed will not hydrolize and therefore will not liberate free alkali. As it therefore retains neutrality when added to water, it is recommended as a medicinal soap or for use on sensitive skin.

Chinese Vegetable Tallow.—This fat from vegetable origin is harder than ordinary tallow and has a limited use in soap making, being sometimes blended with other fats.

Hydrogenated Oils.—In 1903 Normann perfected a process whereby hydrogen could be added to oleic and other fatty acids to produce stearic acid. He found that by exposing these unsaturated fats, in the liquid state, to the action of hydrogen, in the presence of a catalyst, such as finely divided nickel or other metal, the hydrogen was combined and the more valuable stearin produced. The process is commonly applied to whale, fish, cottonseed, linseed, and many other oils and these are used as a substitute for natural tallow.

Rosin.—This substance, the residue left in the still after distilling the oil (spirit of turpentine) from "gum turpentine," is readily saponified and is extensively employed in the formulas for many laundry soaps.

Soap makers claim that this is not simply a cheapener or filler, but that it increases the solubility and lathering properties of the soap and has true detergent value. It is usually found in cheap soaps to the extent of from 15 to 20 per cent.

Tallow.—This substance is obtained from animal fats and is probably the most important soap stock. Its source in the United States is mainly the huge packing houses and this explains why such firms usually conduct a soap factory as a related industry.

Fatty Acids.—Fatty acids are chiefly by-products in the making of glycerin. The fats are treated by one of the well-known processes, the glycerin separated and purified and the fatty acid thus made available for soap making. The soap maker in using this raw

material must take into account the fact that the valuable by-product glycerin has already been removed and, of course, deducts this from the price he pays.

Sodium Silicate is sometimes added to laundry cake soap. It has some detergent value and hardens the soap, preventing wasting. It is found in many of the cheaper laundry soaps.

Alkalies.—As already stated, soda in some form is the most important alkali used in soap making, not only because of its cheapness and availability in unlimited amounts but because the character of the soap it produces, a soda soap being what is known as a "hard soap." The forms of soda most frequently employed are "soda ash," which is a dried form of sodium carbonate and caustic soda (sodium hydroxide), the latter frequently being prepared from soda ash by treatment with lime. Soda in the form of a silicate is used also as a filler (see above). For "soft" soaps and for some other forms of soap, such as shaving soap, and liquid soap, potash, either as the hydroxide or carbonate, is used as the alkali. Ammonium hydroxide is sometimes used but only in special cases, chiefly in the production of soaps to be used as cleansers when mixed with volatile solvents. It is sometimes used as the alkali in the production of vanishing cream, in the form of ammonium stearate.

Kinds of Soap.

Curd Soap.—Curd soap is a soap separated by salt solution, reheated and mixed with sufficient water to form a smooth emulsion, run into frames, cooled, and cut into bars or cakes. It usually constitutes the bar laundry soap. It is frequently strong in alkali and usually contains fillers, such as sodium silicate.

Mottled Soap.—This form of soap shows a streak of color irregularly running through the mass. Originally it was caused by the addition of some metallic salt, as ferrous sulphate, manganese dioxide, or ultramarine. Originally such soaps were considered to be of superior quality, but the effects have been artificially produced, so that today mottled soap does not necessarily indicate a high-grade soap and often containing as little as 20 per cent. of actual fatty acid. The mottled soaps have very largely disappeared from the American market. Mottled soaps are a form of curd soap.

Milled Soaps.—When a high-grade soap stock has been made by the boiling or the cold process, and dried in the frames, it is then

cut into slabs and bars and subsequently chipped. These chips in turn are milled between stone rollers until the soap has acquired a uniform consistence. Such soap is much more serviceable when finally made into cakes and may be variously colored or perfumed. It is possible, of course, to apply this general process to low-class soaps, but whatever the basic stock a milled soap is much more serviceable and satisfactory than the same soap cut directly from the bars.

Soft Soap.—This soap, made from potash, or mixtures of potash and soda, and usually a liquid fat, has already been referred to. It is chiefly used medicinally, either as a cleanser for the hands of the surgeon or for preparing an operating area or in the treatment of the skin or scalp. It is most frequently employed in alcoholic solution under the name "tincture of green soap."

Disinfectant Soaps.—If some form of disinfectant such as cresol, or phenol, is added to soap stock during the milling, the soap is known as a disinfectant soap, even though the amount of added substance is not sufficient to produce effective germicidal action.

Marine Soaps and Hard Water Soaps.—For use with sea water and also for use with water containing lime salts, known as "hard" water, ordinary soaps are very unsatisfactory, because such salts precipitate the soap. It is possible, however, to make a soap which is soluble and therefore usable in such water, by employing cocoanut oil as the fat and possibly introducing a small amount of palm kernel oil. It is this form of soap which is sold under the above names.

Transparent Soaps.—For many years soaps there have been offered which are known as "transparent" soaps. These were originally prepared chiefly from mixtures of cocoanut and castor oils and the resulting soap dissolved in alcohol. When the excess of alcohol was distilled the residue was transparent. It has been found possible in recent years to produce much cheaper and quite satisfactory transparent soaps from mixtures of cocoanut oil and castor oil by the simple addition of cane sugar syrup. Such soap has a tendency to "fig," that is, in time to separate crystalline salts of fatty acids.

Liquid Soaps.—A largely used form of soap chiefly because of its economy and sanitary advantages is known as "liquid soap." This is usually an aqueous solution of cocoanut oil-potash soap, suitably colored and perfumed. It is found in modern hotels and

railroads trains and is used by means of a special apparatus which delivers a few drops of the soap without contaminating the balance.

Floating Soaps.—Floating soap is made by beating the soap in a crutcher soon after running it from the boiling kettles. Air is thus beaten into the soap as it cools and the resulting production is thus made lighter than water. While this lessens the actual weight of soap in a cake it is justified by adding to the convenience in the use of the product.

Shaving Soaps.—Soaps for use in shaving are usually made from carefully selected stock and carefully neutralized, to avoid any caustic action when using on the face. These soaps usually contain a large percentage of cocoanut oil. Shaving creams usually have such substances as tragacanth and milk sugar added in small amounts to increase the permanence of the lather.

Grit Soaps.—For cleaning the hands, when especially soiled with grease or machine work, soaps are offered which contain powdered silica mixed with the soap. Such soaps are frequently in paste form, although they may also be moulded.

Dry-Cleaning Soaps.—Soaps of this character usually consist of an ammonia or possibly a potash soap of oleic acid usually dissolved in a volatile solvent such as benzin. They are used to remove spots in clothing.

Scouring Powders.—Substances of this character sold extensively in a box with a perforated top are not actually soaps. The makers usually claim freedom from alkali or caustic effect. They usually consist of powdered volcanic lava and serve in a purely mechanical function as a cleanser.

How Does Soap Clean? Once more, the question may be asked, "Why soap?" In the opinion of some, soap is used because it acts as a lubricant. Through its use it becomes possible to rub the hands together or more readily scrub clothing or other surfaces and through its mechanical lubricant action the cleansing process is promoted. Another view of the reason why soap is efficacious is the fact that it usually hydrolizes when dissolved in water as may be readily shown by pouring an alcoholic solution of neutral soap into water. In a few moments the presence of free alkali due to hydrolysis becomes apparent if an indicator is added. Phenolphthalein will quickly turn pink, indicating free alkali. Many of the foreign substances on the hands and in clothing which are to be removed, are all of a fatty nature and it is argued that free alkali saponifies

this and thus promotes cleanliness. But while these two explanations of the value of soap are doubtless true and while they in part explain the value of soap, there is another quality which soap possesses, which is related to its colloidal character.

Soap possesses a quality which is known as "adsorption." When it comes in contact with foreign substances it seems to possess the quality of combining and rendering soluble many otherwise insoluble materials. This quality may be very clearly illustrated by mixing lampblack with water and pouring the mixture on a filter. The water will pass through the filter leaving the black, greasy, lampblack on the interior surface. If some soap solution now be added to the mixture in the filter, the lampblack will be immediately carried through the filter showing the peculiar effect of soap on otherwise insoluble substances. If salt is now added to the mixture in the filter, thus precipitating soap, the lampblack immediately regains its insoluble character and will not pass through the filter.

Need more be added to this explanation for the use of soap? It is closely related to the aesthetic side of life. It is a vital factor in the health of every nation. It tremendously lessens the actual labor in the struggle for cleanliness. And the millions of little hands held out daily to be washed are of themselves an adequate answer for the universal prevalence and use of soap.

WHAT SHALL I EAT?

By Horatio C. Wood, Jr., M. D.

Professor of Materia Medica, Philadelphia College of Pharmacy and Science

BEFORE man had invented the arts of agriculture his food supply, dependent largely on the chance result of the hunt, was so uncertain and irregular that he lived almost continuously on the border line of hunger. He could not afford to be concerned about the quality of his nourishment, it required his utmost endeavor to obtain sufficient quantity to meet his absolute needs. There are parts of the world even today where this same condition holds, where it takes only a slight disturbance of the economic balance to drive thousands to eating leaves and filth in the hope of temporarily assuaging the pangs of starvation. But we in America have long enjoyed not only an abundance but even a superfluity of food, so that we are able to pick and choose among the various forms of nourishment. As a matter of fact the American people suffer more from the results of overeating than from lack of nourishment. That the character and amount of food has a profound influence upon the health of the individual has been known from the time, at least, of Hippocrates. Today our minds, and our news-stands, are flooded with a most bewildering variety of all sorts of bizarre regimens by a host of cranks and quacks each advocating vociferously some dietetic fad as the panacea for all human ills. We are alternately urged to eat nothing but raw meat or no meat at all; to live on grass and bran like the cow or on fruits and nuts like the monkey. In the face of such an array of contradictory advice it seemed to me that it might be of interest to briefly review some of the established facts underlying the science of nutrition.

An engine derives its power in the last analysis from the burning—or as the chemist would express it from the oxidation—of carbon, which is found alike in coal, wood or oil. The human body is like the steam engine in that it derives the energy or the force by which we live and move from the oxidation of carbon. What the fuel is to the steam engine, that is food to the body.

Those of you who have had some experience with automobiles know that after a while they begin to wear out, and first one little thing and then another has to be repaired or replaced. The same is true of the body, parts are constantly being injured or worn, repair and replacement must go on practically continuously. The material for the repair of our bodies must also come from our victuals. We therefore require two kinds of food supplies, one containing carbon from which we derive heat and energy, and the other containing those materials necessary for the reparatory processes. I shall call these two classes fuel foods and body builders.

The fuel foods are carbonaceous and can be sub-divided into three groups—the carbohydrates, including starch and sugar, the fats and the proteins. I want to emphasize at this point a very important fact, that very few of our eatables belong exclusively to any one of these three classes. They are nearly all mixtures. Everyone knows, for example, that milk is a complete food; it must therefore contain sugar, fat, protein, and minerals. Not everyone realizes, however, that bread also contains all three kinds of nourishment, and that beets, peas, chocolate, carrots, pumpkins, and many other common articles contain all of these necessary elements. There is, however, a great difference in the proportion of one or the other, thus bread contains very little fat but a very large amount of starch. On the other hand, chocolate is very rich in fat, peas contain relatively large quantities of proteins.

TABLE I. CLASSIFICATION OF FOODS.

Fuel Foods			*Body Builders*		
Carbo-hydrates	*Fats*	*Proteins*	*Mineral*	*Vitamines*	*Proteins*
Sugar	Butter	Milk	Milk	Milk	Milk
Bread	Meats	Meat	Water	Orange	Meat
Cereals	Eggs	Eggs	Green	Tomato	Eggs
Potato	Cheese	Cheese	Vegetables	Cabbage	Cheese
Fruits	Nuts			Etc.	

There is also great difference in the proportion of total nutritious substances. One good slice of bread contains as much nourishment as one-half pound of carrots, and one would have to eat about twenty pounds a day of such food as celery to get the required amount of nourishment.

We measure cloth by the yard, liquids by the quart and nails by the pound. In the same way we measure the fuel value of our victuals in terms of "calories." It would serve no useful purpose for the present discussion to give the scientific definition of the word calorie; I can perhaps convey an idea of the meaning of the word by saying that the ordinary adult requires from 2000 to 3500 calories a day according to various conditions I shall mention later. When we wish to speak of a food quantitatively we say that, for example, a man should eat so many calories of this or that food.

Lists showing the energy value of various foodstuffs have been frequently published and are available in numerous works treating of dietetics. It does not seem necessary for the present purpose to repeat these *in extenso,* but it might be instructive to select a few common and typical foods in order to convey a general idea of the amounts required. Conveniently, foods may be arranged into three groups from the standpoint of their nutritive value, highly concentrated foods, intermediate, and those but slightly nutritious. Among the first group would be included meats, fish, eggs, bread, cheese, nuts, etc., the second group would include milk, potatoes, peas, lima beans and most of the cereals. The foods whose caloric value is relatively low include generally the green vegetables such as string beans, lettuce, onions, spinach, tomatoes, cabbage and the like. An idea of the relative nutritiousness of some of these can be obtained from the accompanying diagram. To furnish 2400 calories which we may take as a fair daily requirement for the city dweller, would necessitate about 1½ pounds of roast beef, three pounds of bread, 3½ quarts of milk or 4½ pounds of fresh peas. It will be noted what very large quantities of green vegetables are required.

There is another factor which must be considered in this problem. Not only must our food furnish a total of some 2400 calories a day but about 400 of these ought to be in the form of protein in order to provide necessary repair material. From this point of view it will be noted that the green vegetables fare still worse as most of their food value is carbohydrate. The sixteen pounds of cabbage required to furnish 2400 calories would furnish only about 320 calories in the form of protein.

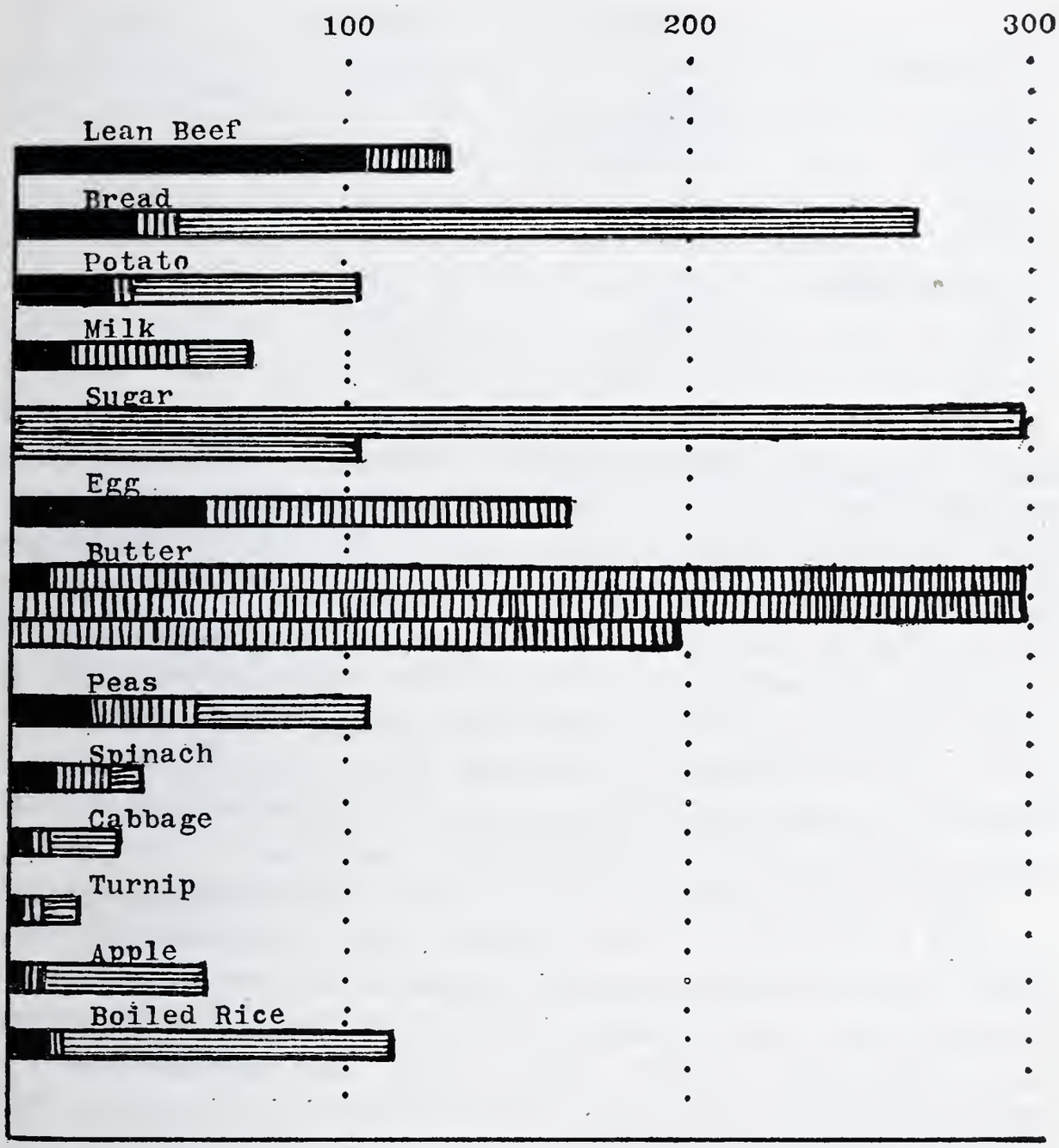


Diagram to Show the Caloric Value of Certain Food-stuffs.

The columns represent the calories in 100 Gm.

Protein Fat Carbohydrate

TABLE 2. TO SHOW THE NUTRITIVE VALUE OF ORDINARY PORTIONS OF SOME FOODS.

	Helping	*Weight*	*Value*
Roast Beef	1 slice	1½ ozs.	125 calories
Potato	1 large	3 "	100 "
Spinach	2 tablespoons	3 "	50 "
Cheese	1 cub. inch	½ oz.	60 "
Milk	1 glass	6 ozs.	120 "
Bread	1 thick slice	1½ "	125 "
Shredded Wheat	1 biscuit	1 oz.	100 "
Egg	1 large	2 ozs.	95 "
Sugar	2 teaspoons	½ oz.	60 "

With this brief review of the underlying facts, we are now ready to meet the practical questions—What and How Much Shall We Eat? Any answer to be of real use must be in practical terms. It can serve no useful purpose to learn the number of calories per pound of each food, for no one is going to take his scales to the table and weigh each piece of pie and measure each bowl of soup, to say nothing of taking the time to calculate from the percentage of carbohydrates and proteins given in the table the exact amount of each class he is ingesting. To be sure there is one large restaurant company that publishes the approximate food value of their various dishes, but even this is of little practical assistance.

The Creator endowed man with an intuitive guide as to the quantity he should eat. In the natural state the appetite is a very useful indicator of the amount of food required. By "natural state" I mean for men who are living in the circumstances for which they were biologically intended. When Adam was expelled from the Garden of Eden he was told: "In the sweat of thy face shalt thou eat bread," and for a true son of Adam the appetite guide is a good one, but for the city dweller whose brow has never known the sweat of physical exercise, it is a most unreliable indicator. I knew two young men who entered the army during the war. They were approximately the same age, in their twenties, and about the same height. When they entered the army one weighed 190 pounds and the other 120; when they were mustered out of the service they weighed respectively 160 and 150. The fat man had grown thinner, the skinny man had become stouter. Both, in other words, had approached to the normal size. After the war they went back to their sedentary

occupations and today the first has gone up to 200 pounds and the other down to 120.

The most reliable and the most practical criterion is the weight of the body. If we are gaining weight it is very certain that we are assimilating more food than we are burning. The life insurance companies have determined by long experience what an individual should weigh. Their conclusions are not based merely on an average, that is by taking 1000 people of a certain height and weighing them and then averaging the total result, but it is determined by finding the death rate of people for each weight, and the figures they give represent the weight which gives the man the most probability of a long life. I am a strong advocate of the habit of regular weighing. I believe that everyone should weigh themselves at least once in two weeks and regulate their mode of living accordingly, especially as to their diet. If you are more than 10 per cent. overweight, go to bed hungry, if you are losing flesh steadily you probably need medical attention.

The amount of food and the kind of food required varies enormously with the age, size, occupation and climate. Children require proportionately much larger amounts of all kinds of food. I say proportionately, because the food requirements are by scientists gauged according to the size of the person. The bigger the automobile the more fuel it consumes, and the same thing is true of man. A little man does not require as much food as a large one. Children require large amounts of energy foods because they are so continuously active; but especially do they require abnormal quantities of the body-building foods, such as the proteins and the minerals, to furnish the material for the growing organism. Probably the two most common errors in the feeding of children are the excess of sugar and the insufficiency of green vegetables. The candy and ice-cream cone and soda water habits are injurious not merely because of the liability of acute indigestion, but chiefly because of the fact that overindulgence in sugar tends to lessen the consumption of more important body-building foods. The constant titillating of the palate by sweets begets an abnormal appetite and the child develops injurious dislikes of wholesome pabulum. The sugar being an easily combustible food, one whose energy can be quickly utilized by the body, satisfies temporarily the natural healthy craving for food, and at the same time the sweet taste tends to kill appetite. The result

of these two factors is that the child who is allowed to indulge in sweets between meals is generally "picky."

Another very important factor which should regulate our food intake is the occupation. Persons of sedentary life obviously need less fuel than those who perform continuous muscular labor. Even the most active use of the brain consumes no perceptible amount of fuel.

As our food furnishes not only the force to drive our bodies but also the heat to keep us warm, the temperature of our surroundings will vary the amount we eat. Those who live indoors need less fuel. It is this heat making quality which is the explanation of the apparent paradox that fat people need less food than thin. Their bodies are protected by a thick overcoat of fat from the rigors of the winter.

Now, just a word about the results of improper stoking of our engines; either too much or too little is injurious. The ills of undernourishment are so well known and the process of starvation so unpleasant that I do not believe it necessary to discuss that phase. But the city dweller is so likely to eat more than he needs that it will pay to stop and see what becomes of the superfluity. Excess of nourishment is stored up in the body in the form of fat which is intended as a reserve supply to tide the body over periods of starvation. A certain amount of bodily fat is very desirable. In the first place, being deposited immediately beneath the skin, it protects the body from the effects of changes in temperature. The whale and walrus can remain comfortable—although both of them are warm-blooded animals—swimming in icy water because of the thick layer of fat which lies under their skin. Moreover, the time is likely to come to any of us, when because of sickness or for some other reason, we may be temporarily unable to obtain the proper nourishment and we shall have to live off of our own fat. There is strong evidence that young people require more fat deposits than in later life. The healthy baby is, to use the common expression, fairly rolling in fat. An adult as corpulent in proportion would be a repulsive object. The statistics of life insurance companies show that the mortality among persons in early adult life, say in their twenties, is decidedly less for those who are a little above the average weight than for those who are below. It is interesting to note that in later

years the reverse becomes true; the man of middle life who is overweight has a greatly reduced expectation of life.

When a person takes in a larger amount of nourishment than is required to furnish energy required for that day, one of two things happens, either a part of the excess is stored up in the form of fat to furnish a reserve against a time of insufficiency, or the unused oversupply may be thrown off by the excretory organs, especially the kidneys. If this performance is repeated one of two things will follow (frequently both). The first is an undue rotundity of figure and the other an excessive burden upon the eliminating organs with consequent injuries to them. If in an automobile we furnish too much gasoline—or as the technical expression is, too rich a mixture—combustion is incomplete and we get an accumulation of carbon. In the same way when the body is furnished too rich a diet the fuel is not completely burned up and there is formed certain substances, the result of this imperfect combustion, which may act as irritants to many of our organs and provoke one or another of a large variety of diseases.

I do not want to scare any of you people who eat too heartily, with a long list of all the horrible things that may afflict the fat man—he has trouble enough already—but I feel that I ought to remind you that there are a number of diseases well recognized to result from overeating and that the life insurance companies feel so strongly on the subject that they will refuse to insure a man who may be apparently healthy in every regard, merely because he is too heavy.

When we come to the problem of the proportion of each kind of food, the practical difficulties are multiplied enormously. As I have pointed out, nearly all foods combine all of the three forms of nutriment in various proportions, and a calculation of the exact amount of each would carry us into the realm of higher mathematics. Scientific exactitude in this matter fortunately, however, is of more academic than utilitarian interest.

Since the carbonaceous foods are useful only as a source of fuel, they may to a large extent replace one another. That is—a man may derive the bulk of his energy from the oxidation either of fats or of starches. In many Asiatic countries the natives use very little fatty food, living almost exclusively upon the starchy cereals. On the other hand, the Eskimo has no access to vegetable foods and takes practically none of his energy in the form of starch.

A Bengalese derives over 80 per cent. of his energy from starch. In this country on an average we obtain about 60 per cent., but among the Eskimos only 8 per cent. of their nutrition is carbohydrate. Energy, as I have already pointed out, can be derived also from the protein elements and this class of food is usually utilized to a greater or lesser extent as a mere fuel. Indeed, among such peoples as are largely carnivorous, like the Eskimos, it becomes a very important fuel.

There are several objections to the adoption of the Eskimo diet of meat and fat for us. In the first place in civilized communities it would be a very expensive form of ailment.

TABLE 3. SHOWING RELATIVE COST OF SOME COMMON FOODS.

Food	*Cal. per lb.*	*Price per lb.*	*Cost per 100 calories*
Beef	675	.45	6.7 cents
Milk	350	.18	5.1 "
Bread	1350	.08	0.6 "
Potato	490	.04	0.8 "
Cabbage	160	.15	9.0 "
Peanuts	550	.60	10.9 "
Chocolate	2700	.80	3.0 "
Eggs (each)	58	.80 (a doz.)	11.5 "
Butter	4100	.45	10.7 "

In proportion to its nutritive value, meat costs about ten times as much as bread. Moreover, man is not naturally a carnivorous animal and it is only through generations of experience that the Eskimo system has accustomed itself to these large amounts of flesh foods. Moreover the proteins have a peculiar heating property which certainly would be injurious at least during the warmer parts of our year.

Nor is the Asiatic diet, cheap as it is, to be recommended. In the colder weather we need the heating property of the protein and it is not at all unlikely that the energy of the dweller in temperate climes is largely due to the stimulating effects of the meat. A purely vegetable diet is as unnatural for man as one of purely meat. Man has neither the tearing teeth of the beasts of prey, nor was he intended to chew cud like the cow.

I am strongly persuaded of the importance of a mixed diet or perhaps I had better say—of a varied diet. This conviction is sup-

ported not alone by the fact that man's digestive apparatus is obviously not purposed for either a purely flesh or a purely vegetable diet, but especially by comparatively recent studies on food chemistry. A few years ago the generally accepted concept among physiologists of the part played by the proteins in nutrition was that they were all brought by the action of the digestive juices to one compound. Now, we know that there are at least sixteen different substances (amino acids) with which the body must be provided by the protein foods. Few, if any, of our foods contain all of these elements, and it is evident that the greater the variety in the source of protein the less is the likelihood of a lack of any one of these amino acids.

The most interesting demonstration of the desirability of a varied diet, however, is the work which is being done with those mysterious elements of our diet commonly called vitamines about which we know almost nothing, except that they are necessary.

Let me tell you two stories, one of a rice-eating people of the Asiatic tropics and the other about a Northern European cattle-raising nation. Two extraordinary diseases appeared at approximately the same time at these widely separated parts of the world. These two diseases, although not unknown before this time, became so prevalent as to make them of economic importance. The symptoms of these diseases in no way resembled one another, and the conditions of living in Scandinavia and Southern Asia are so absolutely different, that it was years before any one dreamt of a connection between these two conditions.

Beri-beri, a very painful condition, is an old tropical disease which has been known to occur now and then among the Asiatics for many years, and was generally believed to be due to some germ. About fourteen or fifteen years ago the incidence of beri-beri suddenly began to increase so rapidly as to become a matter of concern to the Asiatic governments, which led to a more careful study of the conditions under which it occurred. This increase in the disease was practically simultaneous with the introduction among this grain-eating peoples of so-called "polished rice," that is, rice which had been whitened by removal of the outer covering of the grains. As the condition did not occur among those who ate their rice in the natural state, the obvious experiment of testing the effects of the polishings from the rice was tried, and it was found that the administration of this substance at once caused a remission of symptoms.

Economic conditions in the little Kingdom of Denmark are such as to have driven the great mass of people to the dairy industry and they have become the greatest butter producers in the world. About 1910 the demand for butter in the other countries of Europe became so great the Danish dairymen found it a money-making proposition to sell their dairy products and buy other fats to eat. Shortly after this there began to occur a series of cases of a peculiar disease of the eye, especially among children, and which in some cases went on to complete blindness. In the course of the next few years there were some 600 cases of this disease. Shortly after the beginning of the World War the export of butter from Denmark was very greatly reduced because of the activities of the German submarines. With the reduction in their foreign dairy trade there occurred a reduction in the number of cases of this new disease.

We now know that each of these diseases is caused by the lack of some element in the diet, of whose nature, however, we have no definite knowledge. To these hypothetical substances, for the purpose of convenience, has been applied the name of vitamines.

While the subject of vitamines is comparatively new and we have as yet very incomplete knowledge of their nature or role in nutrition, considerable progress has been made. It has been shown, for example, that there is no single, complete, vitamine; there are several substances of this nature which are necessary to make a satisfactory diet. So far three have been definitely established as essential and there is considerable evidence of the existence of a fourth and that others may later be discovered. As we are as yet ignorant concerning the chemical nature of these vitamines, they are usually referred to by letters of the alphabet, as vitamin A, vitamin B, etc. Vitamin A is found chiefly in certain animal fats as egg-yolk, butter and cod liver oil and also in green vegetables. Its absence leads to a peculiar disturbance of the health, the most significant symptom of which is a peculiar disease of the eye, known as xerophthalmia, and, in childen, to cessation of growth. It is not commonly deficient in American diet and may therefore be quickly passed.

Vitamin B is found abundantly in most green vegetables, to a fair extent in natural grains, but is largely removed from the latter in the process of milling and is often destroyed by cooking. It is the substance whose deficiency gives rise to the disease known as beri-

beri. A diet consisting largely of the whole grain of cereal foods will not cause beri-beri, but where these are substituted by polished rice or white bread, this disease occurs unless vitamin B is supplied from some other source.

The absence of vitamin C gives rise to that not rare disease known as scurvy. This vitamin is found in abundance in lemons, potatoes, tomatoes, and to some extent in green vegetables, milk, etc. It is easily affected by heat and in ordinary cooking of these foods vitamin C, although present in sufficient quantity, may be completely destroyed. This is the explanation of the fact known for centuries that raw foods are necessary for the prevention of scurvy.

The existence of vitamin D seems probable, but I do not think is as yet definitely proven. The common supposition is that its absence leads to that very prevalent disease of children known as rickets. There is a good deal of evidence that certain animal fats, especially milk and cod liver oil, are of value in the prevention and cure of rickets.

By experiments upon the lower animals, especially chickens and mice, with chemically purified foods, scientists have worked out the relative amounts of the different vitamins which occur in many of our common foodstuffs. A table showing these proportions has been recently broadcast through the advertising pages of our magazines by one of the large insurance companies. I reproduce it here to show in the first place the amounts of green vegetables in our dietary

TABLE 4. VITAMIN CONTENTS OF FOODS.

	A	*B*	*C*		*A*	*B*	*C*
White Bread	?	+	o	Tomatoes	++	+++	+++
Whole Cereals	+	++	?	Spinach	+++	+++	?
Meat	o	+	+	Cabbage	+	+++	+
Milk	+++	++	+	Carrots	++	++	++
Butter	+++	o	o	Lemon	?	++	+++
Eggs	++	+	+	Orange	+	++	+++
Potatoes	?	++	+	Apple	+	+	+
Oleomargarine	+	o	o	Peas	++	++	+

+ Means small amount.
++ Means moderate amount.
+++ Means large amount.
o Means none.
? Means undetermined.

and also to demonstrate that he who lives on a natural variety of foods need have little fear of vitamin deficiency. I might remark in passing that there is at present no convincing evidence that an excess of vitamin is of any service to the body. The most useful purpose that is served by the different substances advertised to contain concentrated vitamins, is to enrich the manufacturers of these preparations.

In closing this somewhat sketchy outline, may I, as a sort of summary, give a few words of practical advice.

1. Shun the fanatic. It may be assumed that those who deny the validity of the accumulated experience of humanity during centuries, are either motivated by commercial interest or infatuated with unproven theories. All of them are equally irrational.

2. Man is an omnivorous animal; that is, he is biologically constructed to live on a mixture of flesh and vegetable. He is better off with a large variety of food. If it is desirable to lessen the amount consumed, it is better to diminish the quantity of each sort of food rather than diminish the variety.

3. Form the weighing habit and regulate the amount of food you take accordingly. A person who is more than ten per cent. overweight or underweight is not in prime physical health, no matter whether or not they are conscious of any symptoms.

"BRIDGE CONSTRUCTION"

By George Rosengarten, Ph. D.

BRIDGES have existed since the dawn of history; they have served in time of peace and in time of war. With the development of this country the railroads have found it necessary to build bridges of increasing size. The cities on the opposite sides of our great rivers find a connecting bridge necessary to their future development. New York and Brooklyn, Pittsburgh and Allegheny, and now Philadelphia and Camden, have in turn built bridges of great magnitude.

The problems of the bridge engineer include a study of the location, the traffic and the loads to be carried as well as the actual design. As a semi-permanent feature of a community it must combine beauty with utility not necessarily expense and ornament, its lines must conform to the surroundings. Whether we decide on a stone arch, a steel truss or a suspension type, each can be made of sufficient strength, given time and money. Exact computation of the stresses is of comparative recent date. Before 1847 bridge members were proportioned according to the best judgment of experienced bridge builders. Among the early bridge builders let me mention Timothy Palmer, Theodore Burr and Lewis Wernwag, whose work we shall later examine.

Wood, no doubt, was the first material to be used in bridge construction although brick and stone arches date back to 4000 B. C. The great majority of bridges prior to 1860 were made of wood. By 1880, wrought iron was generally used, only to be replaced by steel by 1895.

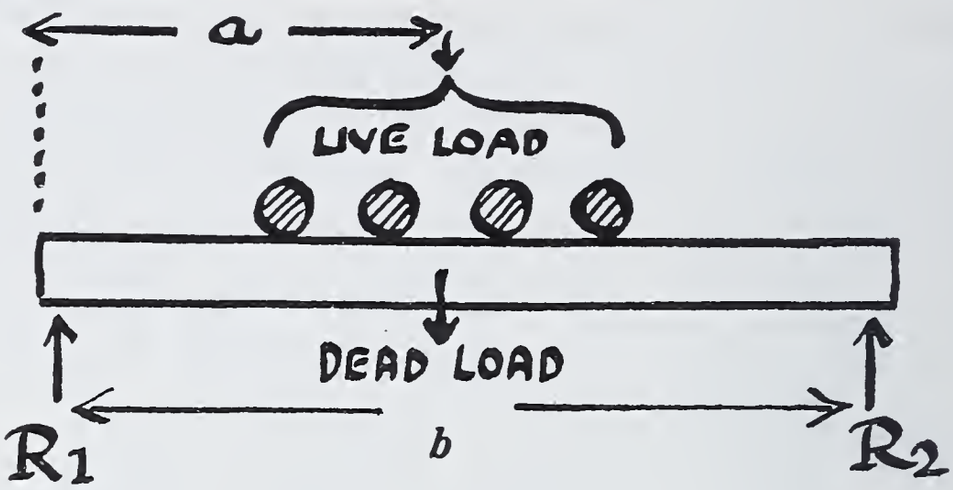
The design of a bridge may be divided into two parts, the so-called sub-structure, including foundations, abutments and piers, and the super-structure, including the roadway supported on the piers.

The simplest bridge consists of a beam supported at its ends. For small spans, that is all that is necessary. Every part of a bridge is subjected to a rigid mathematical analysis. I will not burden you with the details of figures except to point out one or two general principles.

In any design a condition of equilibrium will exist only when the forces up are equal to the forces down.

The upward reactions at the ends of the beam, R1 and R2, must equal the dead load plus the live load. (See Fig. 1.)

As a second condition of equilibrium, we observe that the load upon the bridge has a tendency to rotate the bridge in a clockwise direction about the end R1, and this must be balanced by the counter-clockwise rotation of the reaction R2.



We therefore have two equations:

$$R_1 + R_2 = D + L$$
$$R_2 b = (D + L)\, a$$

To those who have studied mathematics, it will be a simple problem to solve these two equations of equilibrium and determine the reactions R1 and R2.

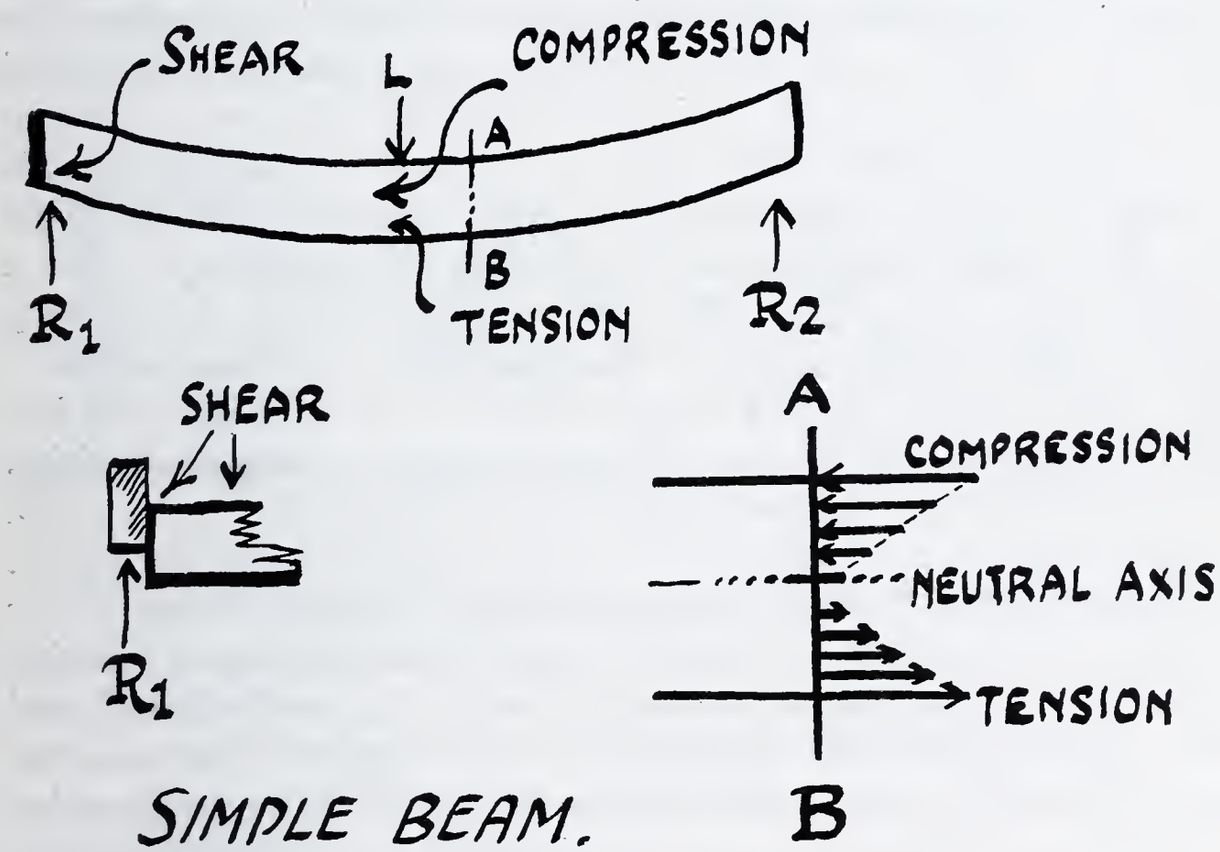
If we apply a load to such a beam, we observe a bending which produces within the beam different stresses, the nature and amount of which we must carefully study in order to determine the size of the beam necessary.

In the upper portion of such a beam we find the particles pushed together, we say in compression, while in the lower portion they are pulled apart, and are in tension. These stresses are maximum at the top and bottom and can be shown to diminish toward the center which is therefore a region of zero stress. A study of the condition at the ends will show the existence of a third kind of stress, called shear, where the material tends to slide one vertical section on another.

If we should use only one support in the center, instead of the supports at both ends, the position of these stresses will be changed. This is the so-called cantilever construction frequently used in long

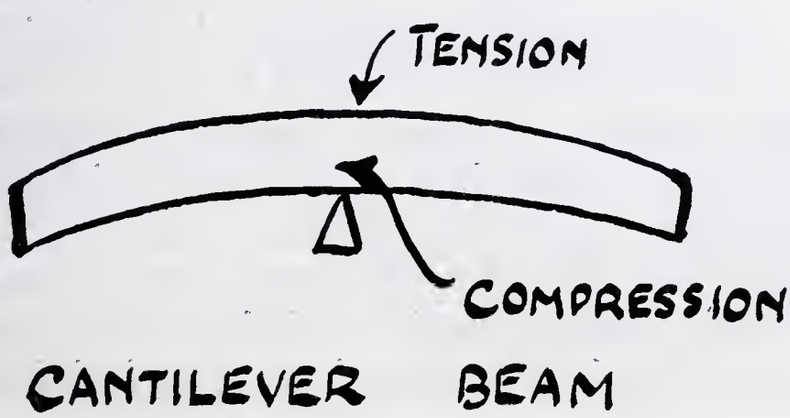
span bridges. In such a beam the stress at the top is in tension, while the stress at the lower side is compression.

This distribution of stress across the section of the beam has determined for us the most economical shape of a beam. The so-called "I" beam is the section used wherever a beam is necessary. The ma-



terial in such a beam is distributed so that the greater amount is in a position to resist the greater stresses at top and bottom of the beam with very little material near the center.

A bridge may be considered to be a large beam. The greater the span the deeper the beam required to keep the stresses within the allowable limits. The determination of the stresses to which vari-



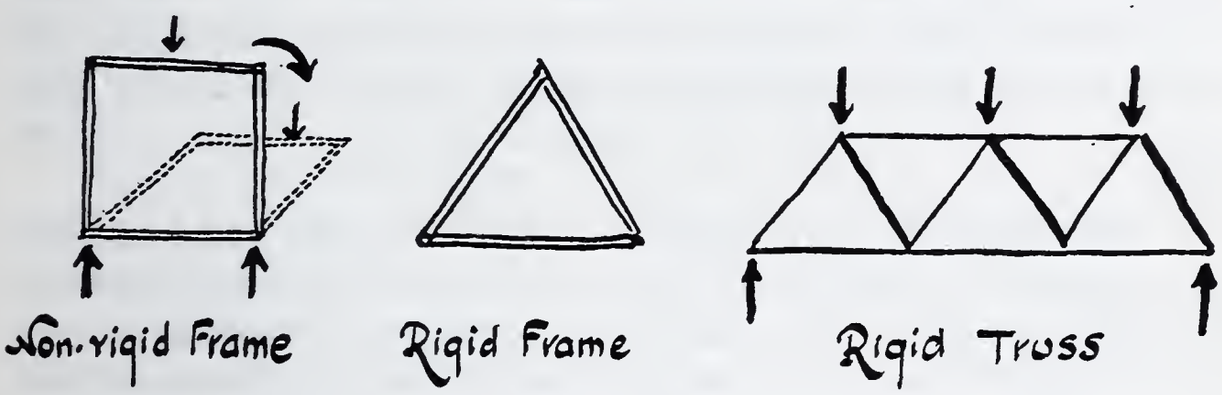
ous materials may be safely stressed is an important feature of bridge construction today. Steel and concrete are the most important materials used. Both of these are manufactured products and must be tested in order to determine the quality.

The simplest test for a piece of steel is the tension test. A small specimen is clamped at the ends in a machine and the load supplied. At first the elongation produced in a piece of steel is proportional to the load. That is, a load of 1000 pounds might produce a stretch of .0001 inch, then a load of 2000 pounds just twice that amount and so on until the so-called elastic limit of the steel is reached. At this loading, we discover the elongation rapidly increases, the test piece becomes thinner and finally at the weakest point, pulls apart like a piece of salt water taffy. While the breaking load for the ordinary grade of steel is 65,000 pounds per square inch, the elastic limit is only about 32,000 pounds per square inch. It is only for loads less than this amount that the material possesses the property of elasticity. It will return to the original length when the load is removed. As a matter of safety, we ordinarily use only 16,000 pounds per square inch, which is well within the elastic limit. In the Delaware River bridge, a special grade of steel is being used, which has a breaking strength of 215,000 pounds per square inch. The production of steel of a uniform grade is an indication of the progress in the manufacture of steel and at the same time has made possible the construction of such large bridges as at present contemplated. In order to study the stresses that develop in the completed structure, models of steel and concrete bridges are built and tested in machines up to 10,000,000 pounds capacity.

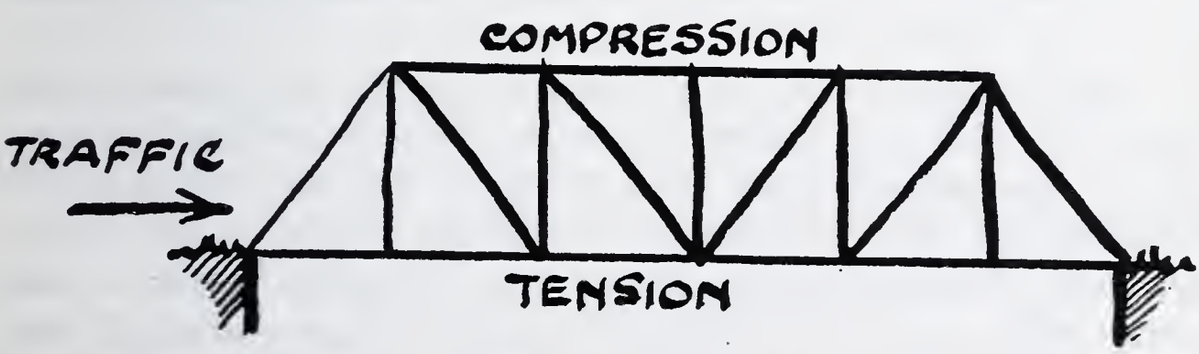
Concrete widely used in bridge construction is a mixture of cement, sand and stone. The cement is manufactured by grinding a limestone to a fine powder and the heating almost to the melting point and grinding a second time. Too much heating and insufficient grinding produce an inferior product. It must be tested. The test best suited to determine the strength of the cement is to mix it with water to form a pasty mass and mould into small briquettes. These are allowed to harden and after twenty-four hours should hold a load of 150 to 200 pounds per square inch, and in twenty-eight days should increase in strength to 500 to 600 pounds per square inch.

As has been stated, the greater the span of the bridge the greater must be the depth. We soon reach the limit for the simple type of bridge we have analyzed. The use of the truss in bridge building

dates back to the sixteenth century. Several pieces of wood or steel fastened together form a truss. We observe that a truss of four pieces fastened at the ends to form a frame has no rigidity, while one of three pieces forming a triangular frame is perfectly rigid and will maintain its shape unless one of the members of the truss breaks. A combination of these triangular frames is also rigid and it is such a truss that we use in bridge construction. In no portion of the truss can we have a frame of four sides.



In any design of simple truss supported at the ends, the top is subjected to a compression and the bottom to a tension, as in the case of the simple beam. We shall consider the truss divided into a number of panels of equal length by upright posts between the top and bottom chords. Each rectangle so formed must have a diagonal member in order to produce a rigid truss.



PRATT TRUSS

In the Howe truss this diagonal sloped toward the support and in order to support the downward weight of the load must be in compression while the vertical members must be in tension.

The Pratt truss has the diagonals sloping away from the support and are subjected to tension. A little consideration will show that it requires a larger piece of material to resist compression than ten-

sion. The amount of material required in the Pratt truss will be less than the Howe truss and it has therefore superseded it in present construction. When the traffic is carried on the lower chord, the two end pieces can be dispensed with and the profile somewhat changed. The bridge truss is symmetrical about the center. The stresses in the top and bottom chords increase toward the center of the span and we find an increasing amount of steel in each panel as we proceed toward the center. The diagonals, on the other hand, are subjected to an increasing stress as we go toward the shore. The center diagonals are very light in weight as they carry only the central load. The stress in each succeeding diagonal will be increased due to the additional load until we reach the end diagonal which carries one-half the load.

Philadelphia has many bridges of different types, and I feel that an examination of them will give us some idea of the problems of the bridge engineer. We shall start our inspection trip back in 1751, when the first survey for a bridge across the Schuylkill was made by a bridge commission, including among their number, Benjamin Franklin. A careful study of the location of a bridge is of prime importance. They reported having sounded the depths and tried the bottom in various places from Peter's Island, near the ford, to John Bartram's, and were of the opinion that the best place was near the end of Market Street, where Captain Coultas then kept his ferry. This earliest proposition for a bridge was a failure, the subscriptions raised among the citizens being too meagre to justify the commencement of the work.

The Schuylkill ferries, the upper, middle and lower ferries, transported their passengers across the river by pulling the boats along a rope running from shore to shore. The first bridge across the Schuylkill was constructed as a military necessity. In December, 1776, General Putnam constructed, on floating barges, a temporary bridge across which the Continental Army passed on their way to Wilmington and Brandywine, following the Battle of Princeton. It was later removed upon the approach of the British to Philadelphia. After the British left it was again replaced only to be washed away by a freshet in 1780.

Not until October, 1800, was the cornerstone of the first permanent bridge across the Schuylkill laid. This bridge was the design of Timothy Palmer. The bridge was a combination of truss and arch design, constructed of wood and covered so as to prevent too

rapid deterioration. Windows on each side admitted light to the interior. The bridge consisted of a central span of 195 feet, and two side spans of 150 feet, built at a cost of $275,000. One cold night in January, 1806, when fire broke out in a tavern nearby, 5000 citizens turned out to assist in saving the bridge, which escaped undamaged. Toll was collected until 1840. In 1850, the bridge was reconstructed to accommodate the Pennsylvania Railroad tracks on the north side, and the tracks of the West Philadelphia Passenger Railway on the south side. The bridge was destroyed by fire in 1875, and for several years a temporary structure was used until the city council, in 1881, passed an ordinance for the construction of the present structure.

It was a remarkable feat of engineering in its day, and Philadelphians were proud of this first bridge. A memorial to this first step in bridge engineering in our city has been preserved in the form of a marble obelisk, which stands at the corner of Twenty-third and Market Streets. It originally stood near the western approach of the bridge. In this day of high speed, few stop to examine its inscription, now almost indistinguishable. The four sides of the monument bore a rather complete description of the bridge and the difficulties attending its erection.

The present bridge at Market Street is a wrought iron cantilever bridge, not often used in small span trusses. Acting like a pair of balanced beams on either pier with a smaller bridge suspended in the center it embodies the principles considered as an alternate design for the Delaware River bridge. In this bridge, the load on the suspended span is transferred to the cantilever arms on either side. The turning effect thus produced about the pier is counter-acted by the weight of the anchor spans, extending to the shore abutment.

The first bridge at the lower ferry, known best to the present generation as Gray's Ferry, from the ferry master, George Gray, was originally a bridge of boats, subject to the action of the stream which on several occasions carried it away. Much confusion and interruption of traffic resulted in the operation of the bridge since the passage of boats and that of wagons from shore to shore could not take place at the same time. Not until 1838 was a bridge of more permanent character constructed at this place by the Philadelphia and Wilmington Railroad Company, whose tracks occupied half of the bridge.

In order to provide for the passage of boats and also that of wagons, with as little delay as possible, some means of quickly opening and closing the bridge is necessary.

The type of bridge used at Gray's Ferry at the present time is a draw bridge. The central span is capable of rotating on the central pier. This entirely changes the nature of the stresses, the top being in tension and the lower portion in compression, whenever the draw is opened for the passage of boats. When the draw is closed, the bridge again acts as a simple beam with compression in the top chord and tension in the lower chord. This necessitates considerable care in design in order that the same part of the bridge shall at one time resist compression and at another tension.

We have record that the heavy freshet of January, 1789, carried away all the floating bridges, including the bridge at the old upper ferry at Callowhill Street. After a similar calamity in 1810, a company was chartered to construct a permanent bridge and artificial roads connecting the outlying districts.

Lewis Wernwag designed and constructed a bridge by spanning the river by a single wooden arch. It was known as the "Colossus," being the largest wooden arch in America, having a span of 340 feet. It was covered, and provided with windows on each side.

After a fire in 1838, which destroyed this wooden arch, a wire suspension bridge was constructed. This was the first suspension bridge of any size constructed in this country. It was opened to the public in 1842. I will leave the description of the suspension type of bridge until discussing the new Delaware River bridge.

Just prior to the Centennial, in 1875, two new bridges were constructed, the one at Callowhill Street, on the site of the wire bridge just mentioned, and the other at Girard Avenue. Both bridges are designed according to the principles of the Whipple truss. It is a double truss, in which the diagonals pass over two panels. The bridge at Girard Avenue was built at a cost of $1,400,000. It has three spans, totaling 1000 feet, and at the time of its erection its width of 100 feet made it the widest bridge in the world. The outer balustrade and cornice are of cast iron with elaborate bronze medalions. Like many other types of bridges, the Whipple truss is not built today.

The largest cast iron arch in America crosses the Schuylkill River at Chestnut Street. This bridge was built during the Civil War, and opened to traffic in 1866. It is very ornamental, cast iron

being adapted to architectural treatment and suffering little from corrosion. With the introduction of steel, iron has ceased to be used in bridge construction.

At the Falls of Schuylkill, in Fairmount Park, several wooden bridges were erected, all of which met the fate of either being burned or washed away. The last was blown down one Sunday afternoon. This is a reminder that the bridge engineer must provide against the force of the wind as well as the loads to be carried across the bridge. The present type of bridge is a double-deck Pratt type of three spans built in 1895. A bronze tablet states that in addition to its own dead-weight, it is designed to carry a uniform load on each deck of eighty pounds per square foot and a concentrated moving load. The lower deck connects the Fall's road on the east with the River Drive on the west. The upper deck was to connect Midvale Avenue with School Lane, according to the city plans, but has never been completed. The view across the bridge shows the provision that has been made to carry an upper deck.

The early development of the railroads running into Philadelphia necessitated the construction of bridges across the Schuylkill. The Philadelphia and Columbia Railroad was the first to build a bridge across the Schuylkill at a point in Fairmount Park just below Belmont Mansion, the home of Judge Richard Peters. It was a wooden, covered structure, designed by Theodore Burr. Opened in 1834, it withstood the elements of fire and water for fifty years.

Let me mention a few peculiar features of this early railroad. After crossing the river the cars were hauled up a long incline plane to the top of Belmont plateau by a rope winding on a drum at the top of the incline. The track, in contrast to our present rails, consisted of a strip of flat iron laid on granite blocks. The rail has long been removed but the granite ties can still be found in many places.

When the Pennsylvania Railroad absorbed the old Columbia, and operated by way of Market Street, this wooden bridge was sold to the Reading Railroad. Because of the increase in weight of the rolling stock, it was necessary to replace this bridge by a series of steel Pratt trusses. By 1917 the increased weight of the locomotives required a further improvement. This time the bridge was constructed of concrete arches.

The rise of the arch being considerably less than the span, we have developed tension near the lower side of the arch. This re-

quires that we use steel bars incased in the concrete to resist this tension.

In the case of the stone arch so widely used, we have no tensile stress. The load is transferred to the abutments through the compression developed between the stones in the arch ring.

In finishing this analysis of bridge construction in Philadelphia, we must consider the design of the largest suspension bridge in the world. All, I dare say, have observed its progress.

The location of such a structure must be given careful consideration with respect to traffic conditions, present and future. The value of the property which must be condemned will influence in a large measure the total cost of the bridge. Of the several locations studied, the one finally decided upon extends from Franklin Square, in Philadelphia, to Pearl Street, in Camden.

Borings on each side and at points in the bed of the river were made in order to determine the nature of the foundation. These borings indicated a layer of sand and gravel sixty feet deep on the Philadelphia side, and ninety feet deep on the Camden side, overlying a rock foundation of mica schist. This rock near the top was rather soft and disintegrated, but increased in hardness with the depth.

The suspension bridge chosen as the type suitable for this large span may be divided into three parts. The piers, the anchorages and the cable with its suspended roadway. The distance between the two piers of 1750 feet, makes this the longest span in the world. The loads to be carried by the bridge are transferred to the main cable by means of vertical suspenders. This load amounts to nearly 60,000 tons, 70 per cent. of which is the deadweight of the bridge, and 30 per cent. that of the traffic to be carried. This live load is based upon assuming all four tracks filled with cars, the fifty-seven-foot roadway jammed with automobiles, and the two side walks crowded with people, this load produces in each cable a maximum pull of 20,000 tons. The cable passes over the tops of the two steel towers to the shore anchorages, which have a weight of 200,000 tons each. It is this enormous weight which keeps the bridge cable in position.

Before examining the details of the various parts of the suspension bridge, let us study an alternate design based upon an entirely different principle. This is a so-called cantilever bridge used for long spans. It has a larger amount of steel than the suspension type, and requires a longer time for erection. It is a truss based upon the same principle as explained in the Market Street cantilever. The

trusses are built out from either side, the turning effect of the cantilever arm is balanced by the reverse turning of the anchor span. New York has used this type in the Queensboro bridge.

In constructing the foundations for the river piers, steel caissons were sunk in the river and excavation proceeded under increased air pressure. Men and material, in entering the working chamber at the bottom, passed through an air lock in which a gradual change in air pressure takes place. The weight of the concrete and the exposed granite facing caused the caisson to sink as the excavation proceeded.

A little closer view will show the men at work inside of the working chamber. The only effect of the increased air pressure being to exhaust them in less than the usual day's labor. If they should emerge from the air chamber too rapidly and come out into the air at normal pressure a serious condition results. Their bodies, being filled with air of high pressure, a severe case of cramps occurs, which can only be relieved by going back into the high-pressure air again.

On top of this foundation has been erected the steel tower which you have observed. It consists of two heavy upright steel posts divided into a number of panels by crossed diagonals in order to produce a rigid structure. Under the varying loads upon the bridge, the top of this tower will swing back and forth twenty inches, thus relieving the strain on the cable. The tower is 347 feet high. Special machines were built by the Bethlehem Steel Company to plane the ends of these large sections so as to give perfect bearing.

Before proceeding, let us consider the Brooklyn suspension bridge. The tower is constructed of stone masonry and the bridge is supported by four cables, which pass over rollers on top of the towers. The enormous weight of the bridge seems to have prevented the rollers from operating, thus throwing increased stress upon the cable.

Only two cables are used in the Delaware River bridge, each having a diameter of thirty inches. Each cable consists of 18,666 wires of .196 inch in diameter. The steel is of very high grade, having an ultimate tensile strength of 215,000 pounds per square inch.

In building the anchorage, it was again necessary to construct caisson with sharp-cutting edges. They were gradually filled with concrete and the material raised from the center by means of large clamshell buckets. At times the caisson would not sink until six or eight feet of earth had been removed below the cutting edge, and

then without warning a drop of four feet or more would occur as the friction on the sides of the caisson gave way. These caissons were all carried to solid rock foundation.

Upon this foundation the anchorage proper was constructed. In order to hold the ends of the cable it was necessary to place within the concrete mass a great many steel bars. After passing over the anchorage cable bent the main cable is separated into a large number of smaller bundles, each of which is fastened to one of the eye bars.

The entire face of the anchorage will be covered with granite block and present a most massive appearance.

A section through the main structure will show the distribution of the traffic. Four lines of cars with a fifty-seven-foot driveway for automobiles. A ten-foot walk above the outside line of cars will accommodate those who walk across the river.

No one can deny that we have not made a step forward. The construction of this bridge will relieve the terrible traffic congestion which has resulted in recent years, and both States will be benefited, and, I trust that every one present will have the opportunity of crossing this bridge some time in 1926.

CHALK AND ITS CHEMICAL RELATIVES

By Edward J. Hughes, P. D.

ORDINARILY we think of chalk as a very common substance. Some of the earliest impressions of our lives are associated with this soft, white, earthy material. Yet it may be surprising to find how much there is to be learned from a study of the substance of which the simple chalk is composed.

Chalk, limestone, marble and coral are all essentially composed of calcium carbonate, commonly called carbonate of lime. We are here to consider the various forms of calcium carbonate this evening. Our consideration will necessarily be limited and yet I feel that if we think about the history and the possibilities in the application of this mineral substance to the affairs of every-day life we cannot help but part with just a little better knowledge and understanding of the world in which we live.

Our present-day knowledge of the origin of calcium carbonate on the earth comes from the silent but undeniable testimony of the rocks. The rocks of the earth's crust may be divided into two great classes, namely, the igneous and the sedimentary. Igneous rocks are those that have resulted from the cooling of a molten mass or magma and sedimentary rocks are those that have resulted from the separation of a solid substance from water. A third type of rock is recognized, namely, the metamorphic, which includes those rocks that may have been of either igneous or of sedimentary origin but which have undergone changes in character because of natural agencies such as heat or pressure or perhaps both. Practically all of the calcium carbonate found on the earth is conceded to be of sedimentary origin. As a result of considerable research work carried on in behalf of the United States Geological Survey, it has been estimated that the crust of the earth is composed of about ninety-five per cent. of igneous rocks, overlaid by about five per cent. of sedimentary rocks. Of this five per cent. about one-twentieth is calcium carbonate.

Among the various forms of calcium carbonate there are sedimentary rocks of different types. Chalk, for example, is a typical

organic rock made up of the shells and remains of some of the simplest living creatures. Limestone and coral are also forms of calcium carbonate that have been produced by living organisms. On the other hand, the stalactites and the stalagmites of the caves, which are largely composed of calcium carbonate, are types of sedimentary rocks that have resulted from chemical sedimentation. Because of its compact, fine-grained structure marble is considered to be a sedimentary rock that has undergone secondary changes through the probable effect of heat and pressure upon shell limestone.

Since chalk and limestone have unquestionably been deposited in the presence of water we find very convincing evidence, in the beds of these minerals that are found in nature, that a considerable area of what is dry land today was at one time submerged.

In North America the indelible record of the rocks shows that the coast at plains of the Atlantic Ocean and the Gulf of Mexico were once under water, and that the North American continent was cut in two by a great mediterranean sea that extended from the Gulf of Mexico to the Arctic Ocean. Later on these waters were withdrawn into the abysmal basins. As a result there are large deposits of calcium carbonate in the great plains and others appearing at some distance away from the coast. These coastal deposits dip toward the sea at a low angle and are covered near the coast by more recent formations.

The period in the earth's history during which these deposits were laid down is referred to as the Cretaceous period, the word Cretaceous coming from the Latin word Creta meaning chalk. Cretaceous beds are also found in Europe, Asia, South America, Africa and Australia. The famed chalk cliffs of Dover are perhaps the outstanding examples of immense Cretaceous deposits that represent the bottom of an ocean in the ages gone by.

It is interesting to consider the various sources of calcium carbonate as it appears on the earth today. First of all there is the form that upon close examination is found to be made up of the remains of countless millions of tiny marine animals. Then there are the shells from thousands of different species of shellfish. Think of the islands, the reefs and the atolls that have been built up by vast colonies of tiny coral animals. Some of the most beautiful cave formations in the world have been produced by the slow separation of calcium carbonate from water in which it was held in solution by

means of carbon dioxide. Air currents enable the carbon dioxide to escape from such solutions and calcium carbonate is deposited. It has been shown that certain vegetable organisms such as mosses, algæ, bacteria and some aquatic plants have been active in the formation of calcium carbonate by abstracting carbon dioxide from water. It has also been found that calcium carbonate is precipitated from sea water by the fermentation or the decay of the albumin present in the organic parts of aquatic animals. This gives rise to the formation of ammonium carbonate which in turn reacts with the calcium sulphate, or other calcium salts in the waters, precipitating the insoluble calcium carbonate. Two clear, well-defined, crystalline forms of calcium carbonate also occur in nature known by the names of calcite and aragonite. Fine crystals of these types have been found and they have probably formed by the slow separation of calcium carbonate from water. The finest crystals of calcite come from Iceland and are known as Iceland Spar. Crystals of Iceland Spar are highly valued in certain optical instruments.

Calcium carbonate is not the only mineral substance that is formed as the result of animal life. Phosphate of calcium and silica are also produced by living organisms, the former being the chief constituent of the bones of vertebrate animals and the latter making up the skeletons of the tiny diatoms and raidolarians.

The story of chalk itself is indeed a romantic one. In 1853 Lieut. Brooke of the American Navy succeeded in scooping up some mud from the bottom of the north Atlantic Ocean. He sent samples of this mud to West Point and to Berlin for examination where it was found to be composed of calcium carbonate and to consist almost entirely of the skeletons of living organisms. Most of the skeletons and the shells found in this chalky mud were observed to be identical with those found in the chalk deposits on dry land today. Later on it was found that a very large area of the floor of the Atlantic Ocean was covered with this same chalky material. It is apparent from this that the ocean is fairly teeming with life and few of us realize the importance of the ceaseless rain of the remains of tiny creatures that drift down into the depths.

In other words, the chalk deposits that are scattered over the earth represent the remains of untold millions of minute organisms that lived in large part floating on or near the surface of an ancient sea. When they died their shells sank to the ocean floor and there

formed a deposit. This is just what is going on over wide areas of the ocean floor today.

Chalk is almost pure calcium carbonate although it is generally mixed with various other mineral impurities. Among the broken skeletons and shells of which it is composed are those of sea lilies, shellfish, sea urchins and many of the simplest living creatures belonging to the group of one-celled animals and included in the class of foraminifera. The remains of millions of these marine organisms may be found in a single piece of chalk.

The most extensive and conspicuous deposits of the true chalk are to be seen in the chalk cliffs of England and France on both sides of the Straits of Dover. Large beds of chalk have also been found under the City of London. A relatively poor grade of chalk is found in Arkansas, Iowa and Texas of the United States, although most of the calcium carbonate found in North America is in the form of limestone and marble.

The chalk flints that are found in the lower parts of some chalk deposits are interesting forms of a rock that is also of animal origin. Flint is an amorphous form of silica, or silicon dioxide, that has been deposited by water trickling through the chalk. The water derives this silica from the siliceous remains of certain sponges and from a group of one-celled animals called radiolarians. Sea water contains very little silica but these little creatures have the power of transforming particles of clay, which is impure silicate of aluminum, into flint of which their skeletons are composed.

Many well-known forms of chalk are met with in every-day life. First of all there is the prepared chalk which is used in medicine and in dental preparations. This is a natural form of calcium carbonate which has been mechanically purified by the process of elutriation or water sifting. Precipitated chalk, also used in tooth powders, is an artificially prepared form of calcium carbonate. It is generally made by mixing solutions of chloride of calcium and washing soda, then collecting, washing and drying the insoluble precipitate that separates out. Immense quantities of chalk are used in the paint industry under the names of whiting, Paris white and English cliffstone. Whiting is also used as a polishing powder and in the manufacture of putty. Gilder's white and Vienna white are purified forms of chalk that are also used as pigments. Then there

are the familiar drug store preparations containing chalk such as gray powder, chalk mixture and chalk and orris.

When we turn to French chalk we are dealing with a mineral substance that bears no chemical relationship to the true chalk but which, instead, is composed of silicate of magnesia. Red chalk or reddle is another mineral substance sailing under false colors since it is composed of clay and oxide of iron.

An interesting fact, not generally known, is that most of the blackboard chalk is now made of plaster or calcium sulphate rather than of the true chalk. The partially dried calcium sulphate used in making these crayons is the well-known plaster of Paris which is capable of taking up water to become hard and rigid in the mold. Various colors may be given to the crayons by adding pigments to the mixture of plaster and water just before molding.

Turning away from chalk the next member of the calcium carbonate family for our consideration is limestone. A close examination of massive or shell limestone reveals its organic origin. In some cases a most entrancing exhibit of minute sea life is laid before the eye. There are shells like those of tiny oysters, tiny clams, tiny snails and tiny things that perhaps you never saw before. While the shells, corals and other remains may be conspicuous in some limestones there are others in which they may be quite obliterated. In much of the compact limestone the shells and remains of which it is composed have been largely ground up by the action of the sea and the waves, and afterwards consolidated. Then it is possible that the calcium carbonate by going into solution and being redeposited has helped to cement and consolidate the limestone. Limestones for building purposes are necessarily compact and thoroughly hardened.

One of the most widely used limestones in the United States is taken from the Bedford deposit in Indiana. There it occurs in massive beds from twenty to seventy feet thick and is said to underlie an area of seventy square miles. The chemical analysis of this stone has shown ninety-seven per cent. of calcium carbonate.

Dolomitic limestone contains varying amounts of magnesium carbonate as well as a large proportion of carbonate of calcium. Much of the common limestone of the United States is dolomitic in character. There is an immense hole in the ground not far from Philadelphia from whence comes a high-grade of this so-called dolo-

mite. It is quarried there by a corporation composed of two graduates of this college in the class of 1873. The magnesic portion of the dolomite is converted into various grades of magnesium carbonate at the largest magnesia factory in the world which is located at Ambler, Pa. Their by-product is calcium carbonate which is used, among other things, as an insecticide in the cotton belt, and for mosquito larvæ, where it is dusted by aeroplanes.

Hydraulic limestone is an impure earthy variety containing clay and is the raw material from which a cement can be made that will set under water.

Lithograph stone is a compact, fine-grained variety of limestone of a very porous nature. Most of the lithograph stones of the best quality have come from Bavaria. These stones can be highly polished and in that condition are capable of taking the finest imprints. For this reason they are used in a valued process of the printer's art called lithographing.

In addition to its use as a building stone, limestone enters into the manufacture of glass, into the production of washing soda by the LeBlanc process and into the making of lime. It serves to remove impurities in the smelting of iron ore and powdered limestone has been found of considerable value in restoring fertility to certain soils that have become sour and acid.

Another well-known member of the calcium carbonate family is marble. The name marble is now given to most any hard, crystalline form of fine-grained limestone that will take a high polish. From its structure and general characteristics we are led to believe that marble is a metamorphic rock that has formed by the effect of enormous pressure and heat upon shell limestone. It has actually been shown that if the pressure is sufficiently great, calcium carbonate may be melted at extremely high temperatures, in a closed vessel, without decomposing, and that the mass upon solidification has a crystalline structure like marble.

The purest form of marble is white. The colored and mottled appearance that is so often observed comes from impurities. The highly prized black marble gets its color from bituminous matter.

A few of the famed deposits of marble that are noted because of the abundance and the quality of the stone, are located at Carrara in Italy and in our own states of Vermont, Georgia and Tennessee.

The Georgia deposit consists of a block of marble four miles

long, three-eighths of a mile wide and two hundred feet deep. This bed is estimated to represent a financial asset to the State of Georgia of more than twelve billion dollars. Its analysis has shown nearly ninety-nine per cent. of calcium carbonate. Some of this stone has found its way into the construction of the Girard Trust Building of Philadelphia.

Immense quantities of marble are used in the construction of buildings, memorials, mausoleums and the like. The magnificent statue of Lincoln at the Lincoln Memorial in Washington is carved out of marble which was taken, by the way, from the terra firma of the old rebel state of Georgia. This heroic statue is twenty feet high, weighs a hundred and seventy-five tons and totals approximately three thousand cubic feet.

Marble dust is familiar to some of us as the name given to one of the earliest sources of carbon dioxide as it was produced for making soda water.

Coral is an organic rock related to chalk in that it too is composed of calcium carbonate. It generally grows in the form of a branching skeleton often assuming beautiful flower-like forms.

The living coral animal is a tiny one-celled individual encased in a hard shell of calcium carbonate which it has secreted. The individuals, or polyps as they are called, consist of little more than a stomach with a mouth surrounded by tentacles. They grow in vast branching colonies, the tiny individuals being sheltered in little cups of calcium carbonate which invests the whole colony.

By their organized and concerted efforts these tiny coral animals have been able to build marvelous creations of nature such as the barrier reefs and the coral islands. When we consider the size of this little animal and how necessarily slow its work must be, then indeed the great barrier reef off the east coast of Australia, which is more than a thousand miles long, truly becomes one of the wonders of the earth.

When the Challenger expedition explored the bottom and the islands of the Atlantic Ocean, in 1873, it was learned that the Bermuda Islands rested upon a lonely column in a deep sea. For a while it was difficult to reconcile this with a conclusion of Darwin's that the coral animal was only active within a hundred fathoms below the surface of the water. Later on, in an effort to secure fresh water by drilling a well down over a thousand feet, it was found that

the limestone and the coral rock formed only the cap to an extinct submarine volcano that reached almost to the surface of the sea.

Many pieces of ornament and necklaces made of polished red coral are composed of the remains of multitudes of these little tropical sea animals.

Considerable superstition was attached to coral and medicinal properties were assigned to it during ancient and medieval times. It is worn in certain parts of Italy at the present time as a charm against the evil eye.

Some of the strikingly beautiful formations of calcium carbonate are the stalactites and the stalagmites of the underground caverns. Notable among these caves are those at Somersetshire, England, the Luray and Endless Caverns of Virginia, the Mammoth Cave in Kentucky and the Carlsbad Caverns of New Mexico.

The names stalactite and stalagmite come from two Greek words, stalactite from a word meaning oozing and stalagmite from a word meaning dripping.

There are mineral formations of rare beauty and splendor in many of these caves and some of them may well be described as subterranean fairy lands. The solvent action of carbonated water upon limestone and the subsequent separation of this limestone from solution has carved beautiful forms resembling chandeliers and large pendants many of which ring like chimes when tapped.

Constant percolation and the dripping of water saturated with calcium bicarbonate causes the formation of the long stalactites of calcium carbonate that hang from the roof of the cavern like icicles. The drops falling upon the floor of the cavern leave a deposit of calcium carbonate in the form of an upright rod called a stalagmite. In some cases the stalactites and the stalagmites ultimately join forming complete pillars in the cavern. In course of time both stalactites and stalagmites, owing to molecular changes, tend to acquire a crystalline structure.

The calcium bicarbonate in solution, which is responsible for these formations, is about thirty times more soluble than the calcium carbonate and the deposits are formed as a result of the escape of carbon dioxide gas from the solution thereby causing the relatively insoluble calcium carbonate to separate.

Other calcium formations that are produced by this same type of chemical sedimentation are the snow-white deposits from

some of the geysers and hot springs, the so-called petrifying springs, and the travertine rock that comes largely from a river in Italy and was used in the construction of St. Peter's Cathedral at Rome.

The subject of shells in itself opens up a vast array of natural forms of calcium carbonate. The mollusks, a group commonly known as shellfish, are the shell builders to which we are indebted for our supply of shells and there are fifty thousand species of mollusks now distinguished by name. The name mollusk comes from the Latin word mollus, meaning soft. The mollusk builds the shell by secreting calcium carbonate from sea water and adding it layer by layer to the growing shell.

The oyster, which is one of our best known examples of an edible mollusk, is pre-eminent as the source of the world's supply of pearls. Not only do the shells of oysters consist largely of calcium carbonate but the highly prized pearl itself is chiefly composed of calcium carbonate which has probably been formed by the oyster about an invading parasite.

Mother of pearl is taken from the lining of shells and pearl buttons are cut from the shells of the fresh water clam. One of the beautiful products of shells that is used as an object of adornment is the cameo. Cameos are generally cut from helmet shells and the finest shell cameos are made in Genoa and in Rome.

Less than fifty years ago there were several forms of calcium carbonate used in medicine. Among these were Prepared Oyster Shell, Cuttlefish Bones, Egg Shells, Powdered Red Coral, Crab's Eyes and Crab's Claws. Most of these have passed out of general use although cuttlefish bones are largely used today in bird cages for birds to sharpen their bills upon. The soft portion of the cuttlebone is still used as an ingredient of various tooth powders.

Let us now consider the nature of this calcium carbonate. It is a compound that contains three simple elements, namely, calcium, carbon and oxygen. In one hundred pounds of pure calcium carbonate there are forty pounds of calcium, twelve pounds of carbon and forty-eight pounds of oxygen, all chemically combined so that the identity of each has been completely changed. When calcium carbonate is strongly heated it loses weight because of the escape of an invisible gas called carbon dioxide. The prolonged heating of a hundred pounds of pure calcium carbonate, until there is no longer any

loss in weight noted, yields forty-four pounds of carbon dioxide and leaves behind fifty-six pounds of a residue called lime.

Now lime and carbon dioxide show a very strong affinity for each other and apparently do not like to remain apart. The result is that when they are brought together, under ordinary conditions, they promptly combine again to form more calcium carbonate. It appears then that there are times when carbon dioxide and lime may be regarded as the descendants of calcium carbonate and the ancestors of more calcium carbonate.

The attraction of lime for carbon dioxide and vice versa may be illustrated by passing carbon dioxide into lime water, which is a solution of hydrated lime. A cloudiness appears in the lime water because the lime is being thrown out of solution as the insoluble calcium carbonate. It is this affinity that makes lime a valued ingredient in mortar since the slaked lime eagerly takes carbon dioxide out of the atmosphere and gradually sets by changing to a stone-like form of calcium carbonate.

Very few chemical substances are better known or have a wider industrial application than lime. It has been known and used since ancient times. Dioscorides described the preparation of caustic lime, by calcining ordinary marble and the shells of snails, nearly nineteen hundred years ago. He also referred to the burning, biting, caustic, scab-making strength of the lime. It must have been known long before then since it has been used in making mortar from prehistoric times.

Lime is generally made by the prolonged heating of limestone or marble at high temperatures. Marble requires a higher temperature than limestone in order to bring about a complete change. Lime which has been burned too strongly is often rejected by workers as being dead-burnt but pure calcium carbonate is not so apt to become dead burnt as that containing impurities of clay or silica.

The limelight, which is now largely replaced by the electric arc, is a blinding, white light produced by exposing lime to the intense heat of the oxyhydrogen flame. Lime and carbon, when heated together in the electric furnace, form a substance that is well-known under the name of carbide. It may be recalled that carbide is the material, which, when treated with water, yields acetylene gas. A great deal of lime enters into the production of a fertilizer material called cyanamide. Because lime attracts water it is used as a drying

agent to remove moisture from many gases. Immense quantities of lime are used in building operations for the production of mortar and plaster. A valuable insecticide under the name of Bordeaux Mixture has been recommended by the United States Department of Agriculture and is composed of slaked lime and sulphate of copper solution.

When lime is treated with about one-half its weight of water a reaction takes place and considerable heat is produced. The lime is then known as slaked lime. If more water is added so that the slaked lime remains in milky suspension the mixture is known as milk of lime and is commonly called whitewash. If sufficient water is added to completely dissolve the lime the result is a solution that represents the well-known lime water of the drug store.

The carbon dioxide that escapes when calcium carbonate is strongly burned has become one of our most serviceable gases. It is constantly being exhaled in the expired air from the lungs of breathing animals. Enormous quantities of this gas have also been given up to the atmosphere during the process of fermentation, in the burning of fuels containing carbon and in the making of lime from calcium carbonate. Notwithstanding all this the atmosphere maintains its uniform carbon dioxide content which is relatively very small. Then what becomes of all the carbon dioxide that is constantly being produced?

The answer to this question involves a most wonderful example of co-ordination in the life processes of the animal and vegetable kingdoms. Green plants have the power to take this carbon dioxide out of the atmosphere, under the influence of sunlight and the chlorophyll that they contain, changing it into nutritious carbon compounds which, in turn, may serve as food for the growing animals. Since carbon dioxide is a heavy gas and a gas that does not sustain life it is only reasonable to suppose that were it not for the activity of these plants in keeping down the carbon content of the air that we breathe, all animal life would perish by suffocation.

Carbon dioxide is without color and odor but like most invisible gases it betrays its presence by what it can do. It is the gas that furnishes the sparkle and the bite to all our soda water and carbonated beverages. The people of the United States have recently consumed sixty million pounds of carbon dioxide within one year in their soft drinks alone. It is the gas that causes the swelling up or the leaven-

ing that gives to bread its desirable spongy character. It has been found to add to the keeping qualities of butter and ice cream when churned with these materials. Cookies and biscuits are preserved in air-tight containers that are shipped abroad by being packed with carbon dioxide. Large quantities of the gas are used in the Solvay process for making washing soda and baking soda. A flame will not burn in carbon dioxide so we find the gas formed and delivered, under pressure with water, from a familiar type of fire extinguisher.

We have already referred to the important part played by carbon dioxide in the formation of limestone caves and caverns and we shall now consider how both carbon dioxide and calcium carbonate give the so-called hardness to water.

Hard water is water that requires an unusual amount of soap to form a lather. Nearly all mineral and spring waters hold more or less calcium salts in solution generally in the form of the bicarbonate or the sulphate. Such waters are said to possess hardness. Waters containing little or no calcium salts in solution generally lather well with soap and are said to be soft. The reason why hard waters require more soap than soft waters to form a lather is because the calcium forms white insoluble substances with the fatty acids of the soap. It is obvious that hard waters are objectionable for washing purposes and it is often necessary to take steps to correct or to remove this hardness.

When hard water is boiled the calcium bicarbonate is decomposed, carbon dioxide is given off and calcium carbonate is precipitated. This treatment is generally sufficient to correct the temporary hardness in any given specimen of water. Any hardness still remaining in the water is called permanent hardness and is generally caused by calcium sulphate or gypsum. In order to remove permanent hardness chemical water softeners such as borax or washing soda are often employed. When temporarily hard waters are used in boilers the calcium carbonate that separates out adheres to the sides and is called boiler scale.

We are constantly learning more and more about calcium carbonate and its derivatives. In this limited discussion we have pointed out sufficient to show how dependent we are upon this interesting group of materials.

It would be difficult indeed to select a mineral substance that tells us more about the history of the earth on which we live than calcium carbonate itself. The immense deposits of chalk, coral, and limestone give mute but positive testimony that millions of tiny creatures lived thousands of years before the dawn of our recorded history. Vast multitudes of these little stone builders are at work this very moment building formations that are not dreamed of today but which will be man's inheritance in the ages that are to come.

CONTROL OF GROWTH IN PLANTS AND ANIMALS

By Arno Viehoever, Ph. C., F. C., Ph. D.
Professor of Biology and Pharmacognosy

GROWTH—the glorious theme in the symphony of life. If all the instruments of the living organism, man, animal or plant, play in tune we have harmony of healthy development. But let one of the instruments play out of tune, and we have as a result discord, disorganization, disease, monstrosity, failure. How is this so?

All organisms consist of minute units, cells; some are unicellular,

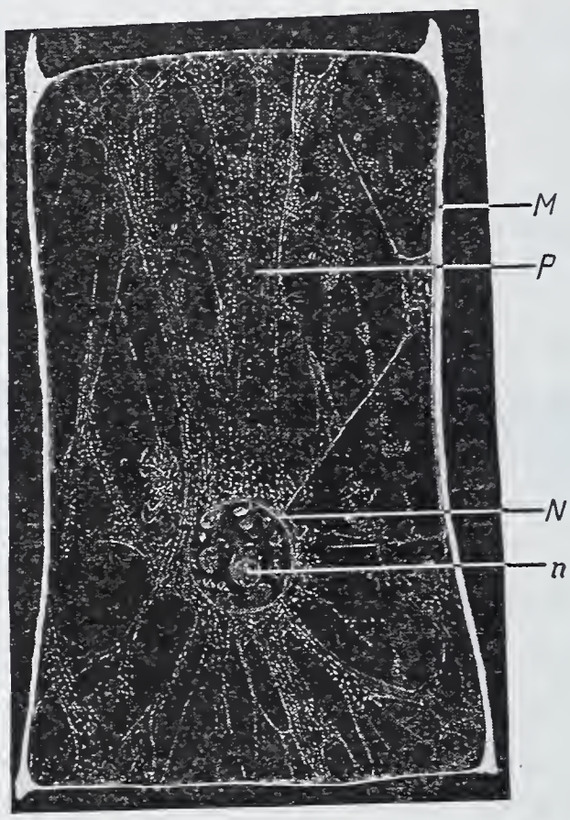


FIGURE 1.

Plant cell. (Hair of Field Pumpkin—Cucurbita pepo.) M.—Membrane. P.—Protoplasm. N.—Nucleus. n.—nucleolus. (After Heidenhain.)

others many celled. These cells, the morphological as well as physiological elements of structure, have within their membrane the life sustaining, butter-like mass "proto-plasm." In it we find imbedded, somewhat as a core, the nucleus, the seat of reproduction and hereditary transmission of characters, and one or more granular bodies (nucleoli). (Fig. 1.) The cells live through a continued exchange

of substances within and without. Form-development, energy transformation and metabolism, the upbuilding and breaking down of the proto-plasm, are the common manifestations of life.

I.

Nature of Growth.

Growth is the outstanding consequence of all development, of the single cell, as well as of the whole tissue. In the growing cell we have a continued sequence of different conditions of metabolism in slow transition, each following condition resulting, necessarily, from the foregoing. Through gradual assimilation of new matter into the living organisms the cell is expanded, divided, the tissue increased in volume and diversified in form and function. This process does not take place with uniform velocity throughout life. Periods of slow growth are followed by periods of relatively rapid growth, which in turn are succeeded by a period of slow growth. This growth in "spurts" is well known in children, animals and plants. Generally speaking, youth, maturity and old age constitute the three stages of growth. In youth we find growth accelerated, in the mature period progressing steadily and in old age, retarded.

In contrast to dead systems we find in living organisms highly complicated protein molecules. Their metabolism is likely predominately responsible for the living process.

Form and Function.—Living organisms or certain of their parts have often been compared with machines. The recognition, centuries ago, of such facts as the heart-functioning like a force-pump, or the limbs being moved by a system of levers, has stimulated many fruitful investigations. While the comparison of the powers of *life* with the workings of machines is still greatly inadequate, we realize clearly, today, the interdependent character of function and structure. Function produces structure, while structure modifies function. The more differentiated the structure, the greater the possibilities of function.

We find also, a remarkable adaptability of organisms, in form and function, to conditions as they occur in nature or as they may be brought about experimentally. Some animals, for instance, are eminently fitted for their life in water, others for their existence on land or in air. While a subject of experimental growth, it may be mentioned here that tadpoles, if prevented from reaching dry land at a certain stage of development, never complete their life cycle. They

retain structure and function suitable for life in water and thus never reach the frog-stage. In our own experiments the animal grown and kept, practically from the beginning, in a well-filled aquarium for about four months never threw off its tail and never developed legs. We shall mention further examples of experimental growth later on.

FIGURE 2.
Very Old Japanese Pine. Dwarfed through starvation and malnutrition. About one yard high. (After Molisch.)

II.

Essentials of Growth.

Nutrients.—Of the eighty-seven known elements, thirty-four have been found to enter into living proto-plasm. Thirteen are invariably found and seem to be on the whole essential to life. These are Hydrogen (H), Carbon (C), Oxygen (O), Nitrogen (N), Phosphorus (P), Sulphur (S), Potassium (K), Magnesium (Mg), Calcium (Ca), Iron (Fe), Sodium (Na), Chlorine (Cl) and Silicon (Si). The percentage of elements found in an organism stands in no relation to their abundance in nature, in soil, water or atmosphere. The following elements, arranged in the descending order of their percentage occurrence, have recently been reported for man, O. C. H. N. Ca. P. K. S. Cl. Na. Mg. I. F. Fe. Br. and Al.; for gymnosperms (pines and other coniferous trees) C. O. H. Al. Si. S. F. N. Ca. K. P. Mg. Cl. Na. F. Mn.

Serious disturbances in growth are soon observed when only one of the essential elements is wanting.

Of course we find structural modifications which either reduce the need for constant supplies of water, or which, as in the case of certain desert plants, reduce the amount of water given off through transpiration. The author found even hygroscopic substances (saponins) in the cellsap of yuccas and agaves, growing in arid regions. An example for crippling life through systematic starvation is presented in the Japanese pine-tree, which is skillfully kept from natural death. (Fig. 2.) The resurrection plant (Selaginella), and in the

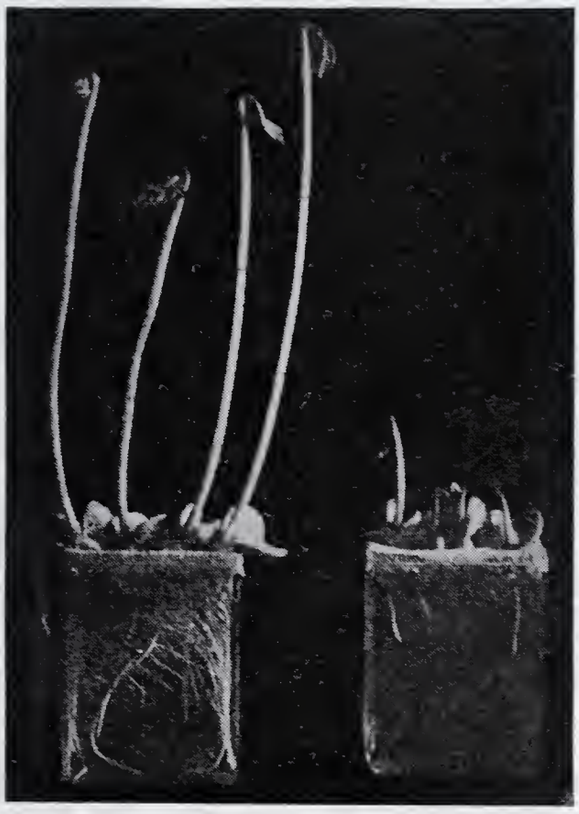


FIGURE 3.

Need for Lime (Calcium) in Plants. Embryo of Spanish Bean. (Phaseolus multiflorus.) Nutrient solution with calcium. Without calcium. (After Molisch.)

animal kingdom the bear-animalcules, "Macrobiotus Hufelandi," are forms of life which may exist in air-dry conditions, though this form of life may be designated merely as latent. The need for lime (calcium) in the formation of cell structure in plants and bones in animals can be readily demonstrated. (Figs. 3 and 4.) That the lack of lime especially in early childhood is mainly responsible for the later decay of teeth appears proven by the experimental work of McCollum, of Johns Hopkins University. The lack of other bio-elements causes other changes of more or less serious character; without phos-

phorous no nucleus, without hydrogen, hydrogen and carbon, no proteins could be formed; without magnesium no chlorophyll could exist; without potassium the proto-plasm would be incomplete, and so forth. That the presence of certain amino acids in the proteins is also essential and that some, like wheat proteins, through lack of

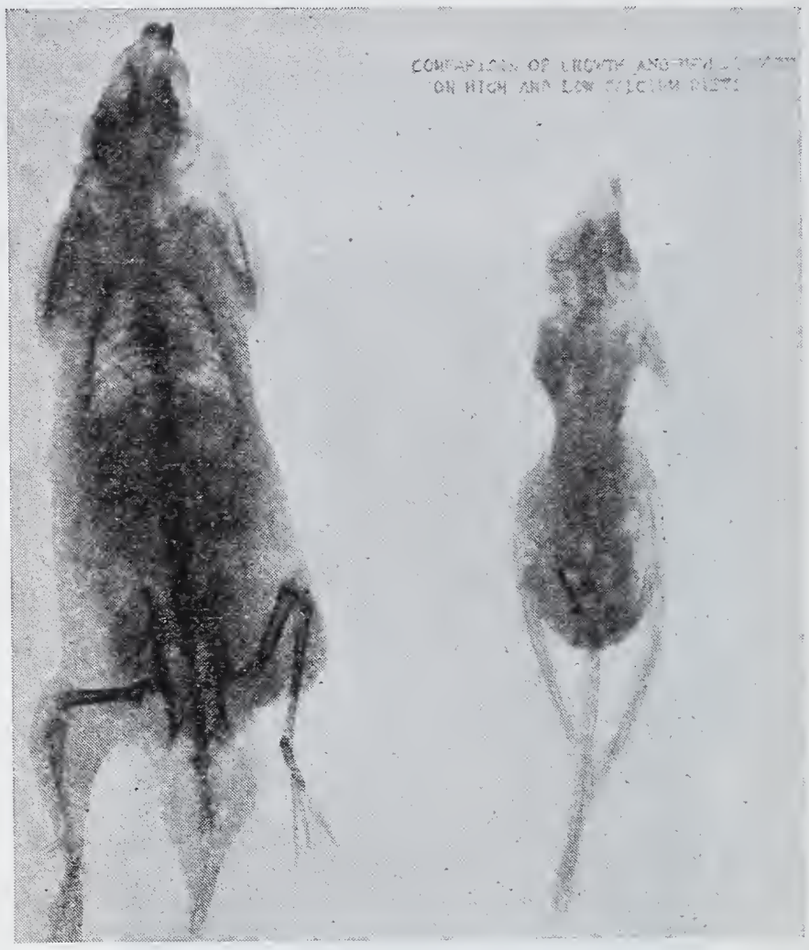


FIGURE 4.

Need for Lime (Calcium) in Animals. Rats of the same age—on experimental diets for about five weeks. Diet high in calcium, low in calcium. (After Mendel. X-ray-photograph after Mitchell.)

lysin, or others through lack of trytophan, etc., are deficient for food or feed, has been conclusively shown by experiments of McCollum, of Mendel and Osborn, C. O. Johns and others.

Vitamins.—To these bio-elements, essential to satisfactory nutrition, must be added a group of substances to which the name vitamin has been applied by their discoverer, C. Funk. Their chemical nature is unknown,* with exception of one, "Bios," D II, a crystal-

*Jakahashi just claims to have isolated vitamin "A" as a yellowish red oil, resembling in composition and behaviour cholesterin and called therefore "biosterin."

line substance with a pyrrole ring; the source of the various vitamins and the diseases prevented by their presence are, however, well established now.

VITAMINS.

Nature.	*Sources.*	*Presence Prevents:*
Vitamin A	(a) Butter-fat, cod liver oil, (b) Green leaves (not fat soluble form)	Xerophthalmia (atrophy of inner eyelid)
Vitamin B	grains yeast	Polyneuritis in infants, Beri-Beri.
Vitamin C	fresh fruits vegetables	Scurvy
Vitamin D I	Cod liver oil	Rickets, "English disease"
Vitamin D II	grains yeast	lack of growth of mammals, Beri-Beri.

That vitamins, found to be necessary in animal nutrition, are also essential in plant metabolism may be assumed from their abundant occurrence in lower and higher plants. Even in bacteria vitamins have recently been found.

Endocrine Products.—In addition to bio-elements and vitamines, the animal body needs for its satisfactory development and functioning a number of secretory and glandular products. An illustrated sketch indicates their location and the tabulation refers to location and function of the glands. (Fig. 5.)

ENDOCRINE GLANDS.

Gland.	*Location.*	*Function.*
Pineal	In the brain	controls puberty, affects sex development.
Pituitary	Front base of brain	controls growth of skeleton and affects brain and sex tone.
Thyroid and Parathyroid	Both sides of larynx	affects brain and sex tone.
Thymus	Rests on the trachea	controls sugar metabolism of the body.
Adrenals	Top of kidneys	glands of combat; affect growth of brain and sex glands, also add energy for emergency.

Of these products only adrenalin has been satisfactorily studied and even synthesized. Other substances, as thyroxin, have been isolated as crystals, while insulin is thus far only known as an amorphous substance. The fact that some constituents present in glandular products have been observed by Slothower, and later by the writer, to occur in a crystalline condition, should facilitate the problem of isolation and study.

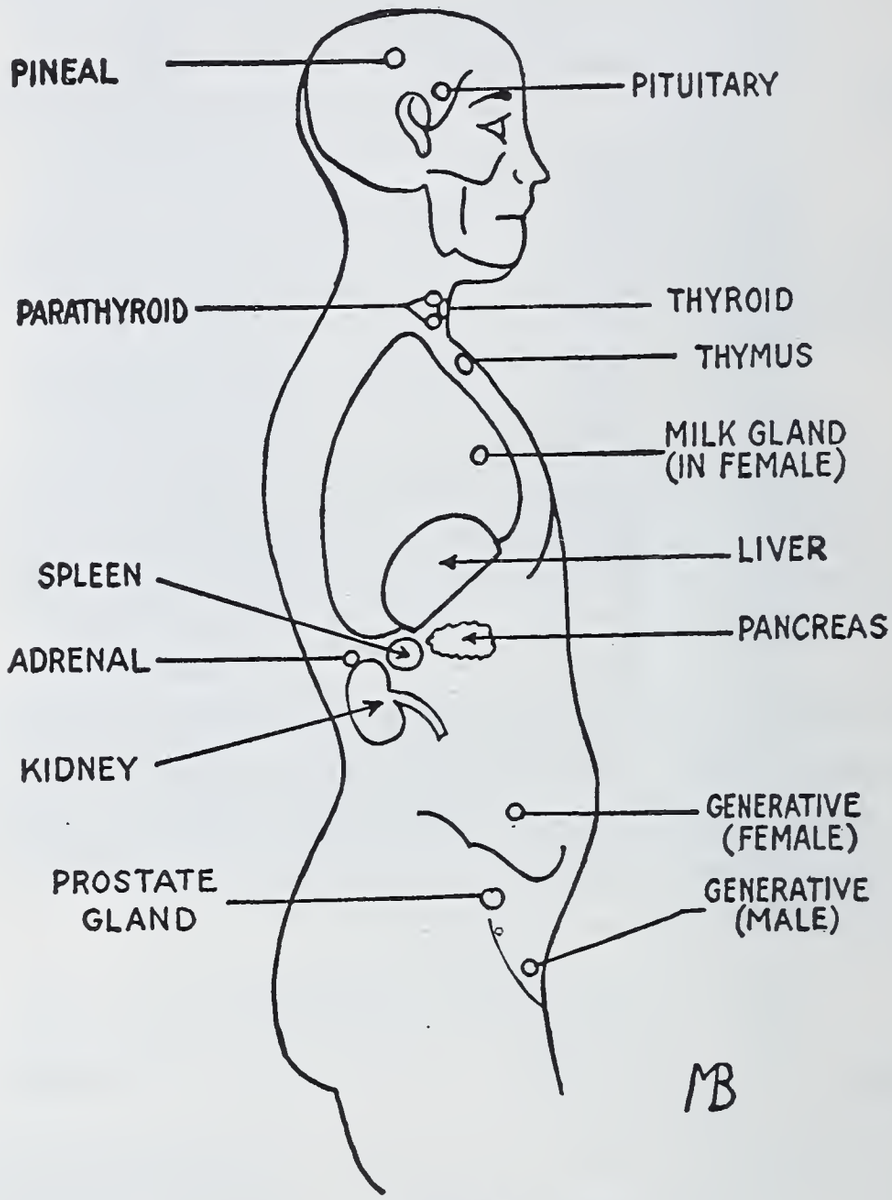


FIGURE 5.
Schematic Chart of the Endocrine System. (After Kammerer.)

III.
Unicellular Organisms.

Normal Growth.—The organisms consisting of but one cell show an adaptability in form and function which makes their study especially interesting and fruitful. They are on the borderline, with characteristics which place them in the classes of both plants or animals. In the large class of bacteria we find representatives which

utilize, as forms of energy, certain constituents of the substrata, such as, cellulose, sulphur, urea, etc., to such an extent that they provide practically exclusive conditions of growth.

Others get along better in mixed cultures. To demonstrate the extreme variability of form and function, we might mention as an example the Azotobacter, which is characterized by the morphological and physiological behavior of seven different cell types which could all be transformed into each other.

1. Large, non-sporulating, globular, oval, rod-like cells of white, yellowish or brown color with polar or peritrichous flagella.
2. Small, spherical, "Coccoid" cells of white, yellow or pink pigmentation, the vegetative growth of the regenerative bodies.
3. Dwarfed cells of yellow, white and red color, the vegetative growth of the gonidia.
4. Irregular, fungoid cells, producing a yellow, orange, white or pink growth.
5. Small, non-sporulating rods of white and yellow color.
6. Small sporulating rods.
7. Large sporulating cells growing white, yellow and brown.

Thus it was shown by Löhnis that the different development stages of Azotobacter could be in part identified with certain so-called species belonging to the form genera Micrococcus, Bacterium, Pseudomonas, Bacillus and Mycobacterium. A sketch is submitted to show the various forms in addition to an unorganized slime mass (symplasm). (Fig. 6.)

The attempt to obtain cell-division, and thus vegetative reproduction, in these unicellular organisms has been altogether successful. Several workers, among them the author himself, in his work with urea bacteria, have produced, by frequent transfer of culture to culture, thousands of generations of bacteria through vegetative reproduction only. Thus these cells, multiplying through simple division, may justly be considered as immortal organisms, always giving off some of their plasma to the cells of following generations.

Abnormal Growth.—The growth of organisms on unusual substrata often brings about peculiar adjustments in form. Such modifications have been until recently referred to as involution forms, now they are known as chemomorphoses. A form transformation may readily be observed on such micro-organisms as Protozoa, which through altering the composition of media and modification of temperature, may assume different shapes, and may move either more

lively upon rise of temperature or remain altogether stationary upon cooling of the substrata.

That, through changing of the substrata, the products of metabolism may be greatly altered, has been strikingly shown especially by

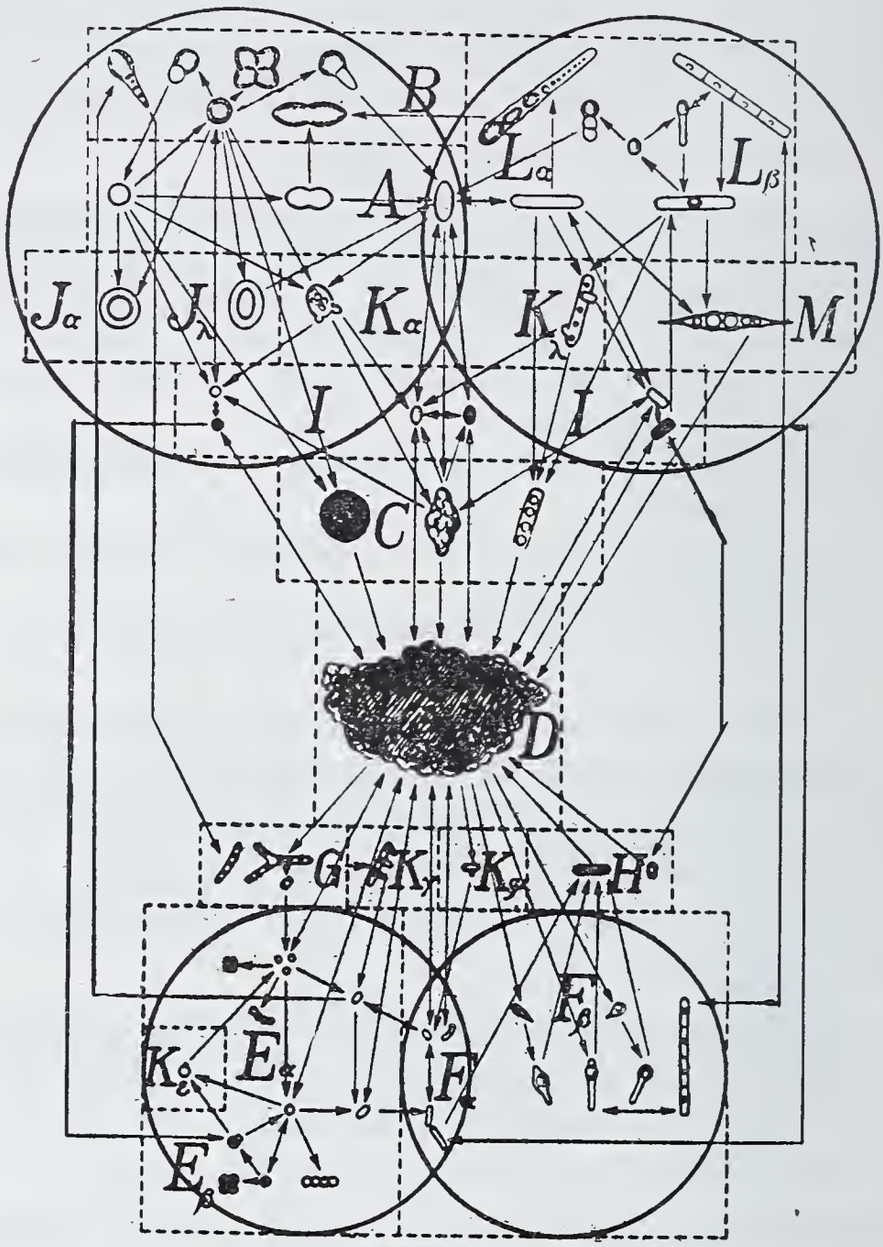


FIGURE 6.

Lifecycle of Bacillus azotobacter. The broken straight lines divide the different types of growth indicated by the letters A to M. The Greek letters α to λ refer to subdivisions. The single- and double-pointed arrows indicate the development of one form from another. The four circles confine, in every case, all those forms which represent together a rather constant mode of life and which have been usually considered as bases for establishing separate species. (After Löhnis and Smith.)

Carl Neuberg, who grew yeast in alkaline culture media and thus produced glycerine up to 14 per cent.

Many methods of differentiating lower organisms, *e. g.*, by formation of gas, acid, enzymes, pigment are based on the significance and use of specific culture media.

IV.

Higher Organized Forms.

Normal Growth.—In the higher organized plants and animals we observe increased differentiation of cells, and an increase in tissues with specific functions. Cells, as plant fibers and muscle fibers, having similar functions of strengthening, have also similar structure. All cells start normally through division of the egg-cell; meristematic or embryonal tissue then develops and all the cells needed in

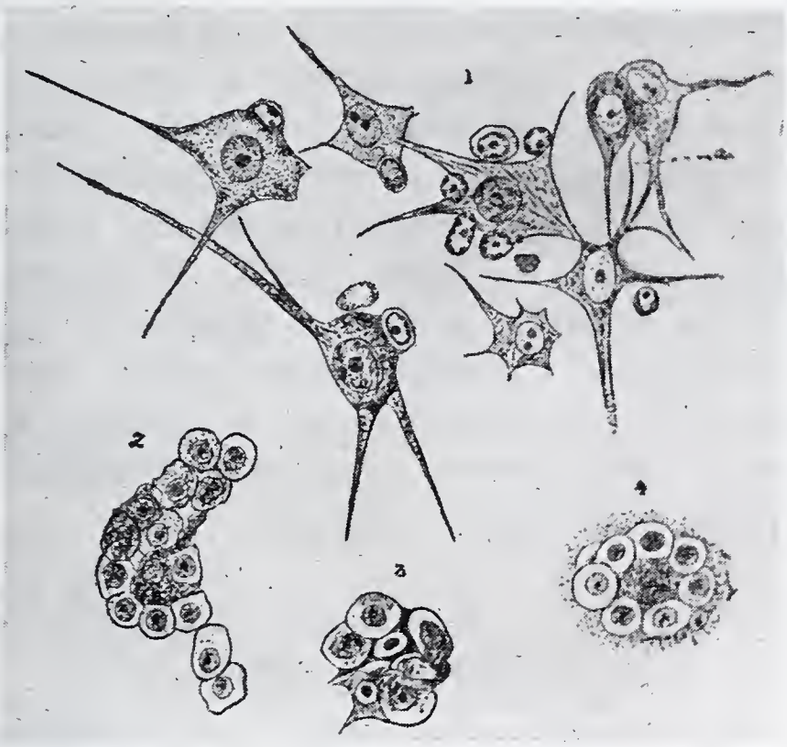


FIGURE 7.

Aging of Cells and Tissues. Nerve cells surrounded by neurophages—phagocytic cells, by which they are gradually destroyed. This form of phagocytic activity only occurs during old age. (After Metchnikoff.)

the metabolism of the organisms are subsequently formed. The increased differentiation permits of a complicated mechanism; it demands, however, continual co-operation of all parts and has also the disadvantage of decreased power of regeneration.

The aging of cells and tissue, which cannot be stopped, ultimately brings about a degeneration, an inability to function properly, and a general breakdown. An example of aging is the destruction of nerve cells, illustrated elsewhere. (Fig. 7.)

Of interest is the varying age of organisms. We all know annuals among the flowering plants, and others which flower, fruit and die in the second year, still others, perennials, with an indefinite life period.

That death, through disease and other causes of accidental destruction, shortens materially the normal life period is well known. Among the lower plants or animals, we have learned to know the bacteria and other unicellular organisms which we can consider as immortal beings. Among the more highly developed organisms, one plant, the California Redwood tree (Sequoia gigantea), has withstood all the forces of destruction, except that of man, for at least 4000 years. The dragon tree (Dracaeno draco), of Orotova on Teneriffe, and the water cypress (Taxodium Mexicanum), growing near Oaxaca in Mexico, bear witness of over 6000 years of existence.

The life period of animals, as that of man, varies greatly. A recent tabulation is included, which, through the placing of question marks, illustrates also the doubt concerning the possible ages. From critical surveys one must conclude that the life period of man at best only slightly exceeds the century mark. Reference is also made in the table to the cephalization factor suggested by Friedenthal. It expresses the relation of the weight of the brain to that of the living body (substance). The highest factor is obtained in the case of man; it decreases with lowered intelligence of animals. The most intelligent animals evidently live longest.

MAMMALS.

Species.	*Cephalization—Factor.* $\frac{\text{Weight of Brain}}{\text{Weight of Living Substance}} = \%$	*Maximal Life—Duration (According to Hanseman) in Years.*
Man,	2.67 to 2.81	80 to 150
Elephant,	1.24 to 1.34	90 to 100
		150 to 200*
Anthropoid Ape,	0.76 to 0.65	50 to 60*
Horse,	0.43 to 0.57	45
Deer,	0.40 to 0.50	30
Bear,	0.36 to 0.50	50
Dog,	0.34 to 0.51	15 to 20
Cat,	0.29 to 0.34	20
Oxen,		
Giraffe,	0.30 to 0.40	30
Antelope,		
Squirrel,	0.16 to 0.20	6
Insectivora,	0.06 to 0.18	6 to 10
Mice,	0.04	3

*According to Korschelt.

BIRDS.

Species.	*Cephalization—Factor.*	*Maximal Life—Duration (According to Hanseman) in Years.*
Carrion Crow,	0.168	100 (?)
Parrot,	0.147 to 0.177	100 (?)
Alpine Crow,	0.114	50
Buzzard,	0.11	...
Owl,	0.113	50*
Finch,	0.086	8
Sparrow,	0.086	...
Duck,	0.0731	...
Snipe,	0.0585	...
Quail,	0.0495	...
Heron,	0.0459	15
Pheasant,	0.0343	15
Fowls,	0.0249	10 to 20
Ostrich,	0.0195	...

*According to Korschelt.

Abnormal Growth—Cancer.—As an example of disease, affecting both plants and animals, cancer may briefly be mentioned, inasmuch as it presents uncontrolled growth, unbalanced development. It has also been referred to by Erwin F. Smith as a phenomenon of continually interrupted healing. One of the causes of plant-cancer, resembling in many ways that of animal tumors, has been shown to be a micro-organism (Bacillus tumefaciens). "We were two years trying to isolate the parasite of crown gall," says E. F. Smith, who has been so successful in his studies of plant-cancer. He inoculates young plants by introducing the germs in buds and other embryonal tissue. (Fig. 8.)

The cause of animal cancer is definitely attributed now to various causes: Filterable virus, worms (cockroach and angleworm nematodes), coal tar preparations, anilin dyes, nicotine and most recently, according to English claims, to an ultramicrobe. Skin tumors, through the frequent application of tar products to the skin of the ear, are more readily produced in pregnant animals, as was recently demonstrated to the writer in the Ehrlich Institute, of Frankfurt, Germany. That the milt plays an important role in the development of animal cancer was recently advanced by Rhoda Erdmann.

Cancers of the lip and tongue are, it is also claimed, caused by nicotine, as a result of excessive smoking.

V.

Experimental Growth.

In the discussion of experimental growth we might well think first of the experiments which have led to a change of sex both in plants and animals.

The work of Correns and others has shown the distinct influence of age of flower pollen (Melandrium) upon the sex of the following

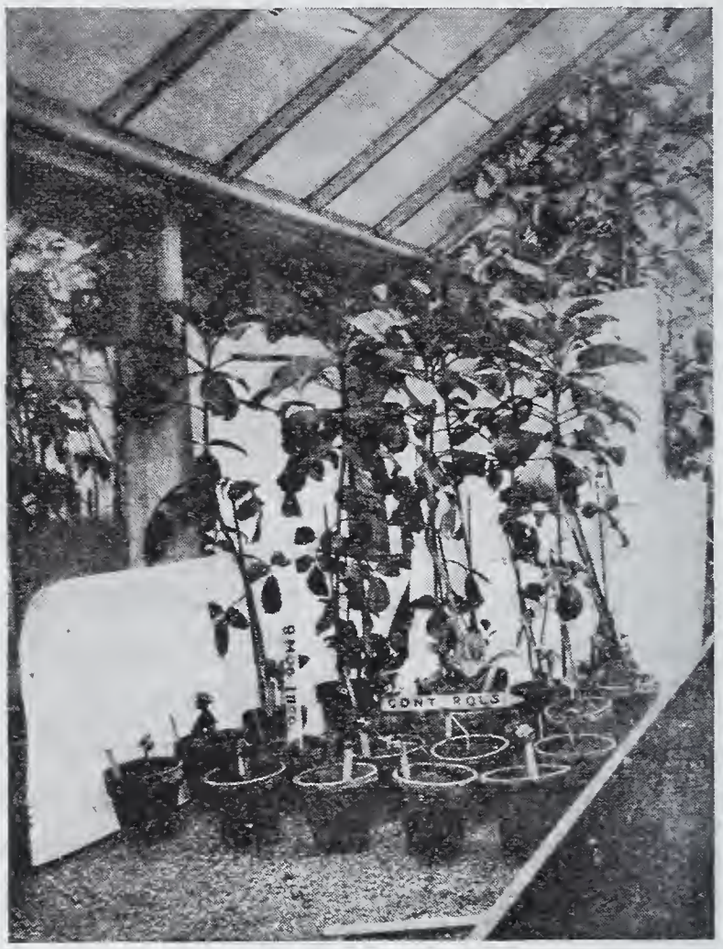


FIGURE 8.

Plant Cancer. Crowngall inoculations on one of the two Lifeplants (Bryophyllum calycinum). Bacterium tumefaciens, plated from a peach tumor, was introduced into the terminal bud region of young plants, which were dwarfed and killed within nine months—while all controls showed vigorous growth. (After Erwin F. Smith.)

generation. The older the pollen, the more male plants were produced. The age of egg cells evidently had no influence.

Even more interesting is the work of Steinach with guinea pigs, changing their sex characteristics at will by transplantation of sex glands. Worthy of note here is the success of Loeb in the chemical stimulation of sea urchin eggs with saponin, a substance reducing

the surface tension of the liquid and causing the development of the egg, or his work effecting the artificial parthenogenesis of a frog.

Regeneration.—The possibility of regenerating tissue, both vegetable and animal, is so well recognized in certain quarters that methods have been worked out, which are applied on a constantly growing scale. The processes of pruning, budding and grafting in plants are but forms of regeneration. As many as 137 different forms of such regeneration have been counted. In nurseries and commercial greenhouses these methods are generally applied. I mention only the benefit to fruit growers, who thus have a means of growing varieties best suited to their particular conditions. The wide distribution of California privet hedges is only made possible by the fact that branches detached from the bush may readily be rooted and produce new plants. There is evidence that embryonal tissue is well distributed in plant life, which tissue will develop to new organs should conditions be suitable for bringing this about. Of interest in this connection is that the author succeeded in producing new growth on a digitalis leaf completely detached from the plant. (Fig. 9.)

Speaking about tree surgery, Peets in his new book on "Practical Tree Repairs," emphasizes the importance of the cambium layer—a very inconspicuous, soft, moist layer between the bark and the sapwood.

"The cambium layer is the great fact to the man who is doing tree repairing. If an accident occurs, his first thought is of the cambium. If he is making an incision or filling a cavity, one eye must be constantly on the cambium. He must learn all its wills and wonts, what it does and how it does it, what can be done to it and what can not.

"For the cambium is the only growing part of the tree (besides the young leaves and the tips of twigs and roots) and if growth is to be made the cambium must make it. It is the vital, growing cambium which each year lays on a thin, strong layer of new wood over the whole surface of the frame of the tree, which builds out a tough shield of bark to protect itself and the wood beneath it. It is the cambium which heals wounds and covers over cavities." To emphasize the marvellous function of the cells, which form the cambium or other embryonal tissues (thin walled, undifferentiated, plastic, unencumbered by vacuoles and secretory inclusions), the author is tempted to refer to them as the "divine" cells.

In animal life various forms of regeneration are possible. In the lower organisms, even from small parts, complete regeneration is possible, provided the nuclear constituents of the cell are transferred.

Budding is readily observed in the development of hydra or sea-star branches, grafting in the case of tadpoles joined together in various ways. Regeneration of skin, nails and hair in human beings

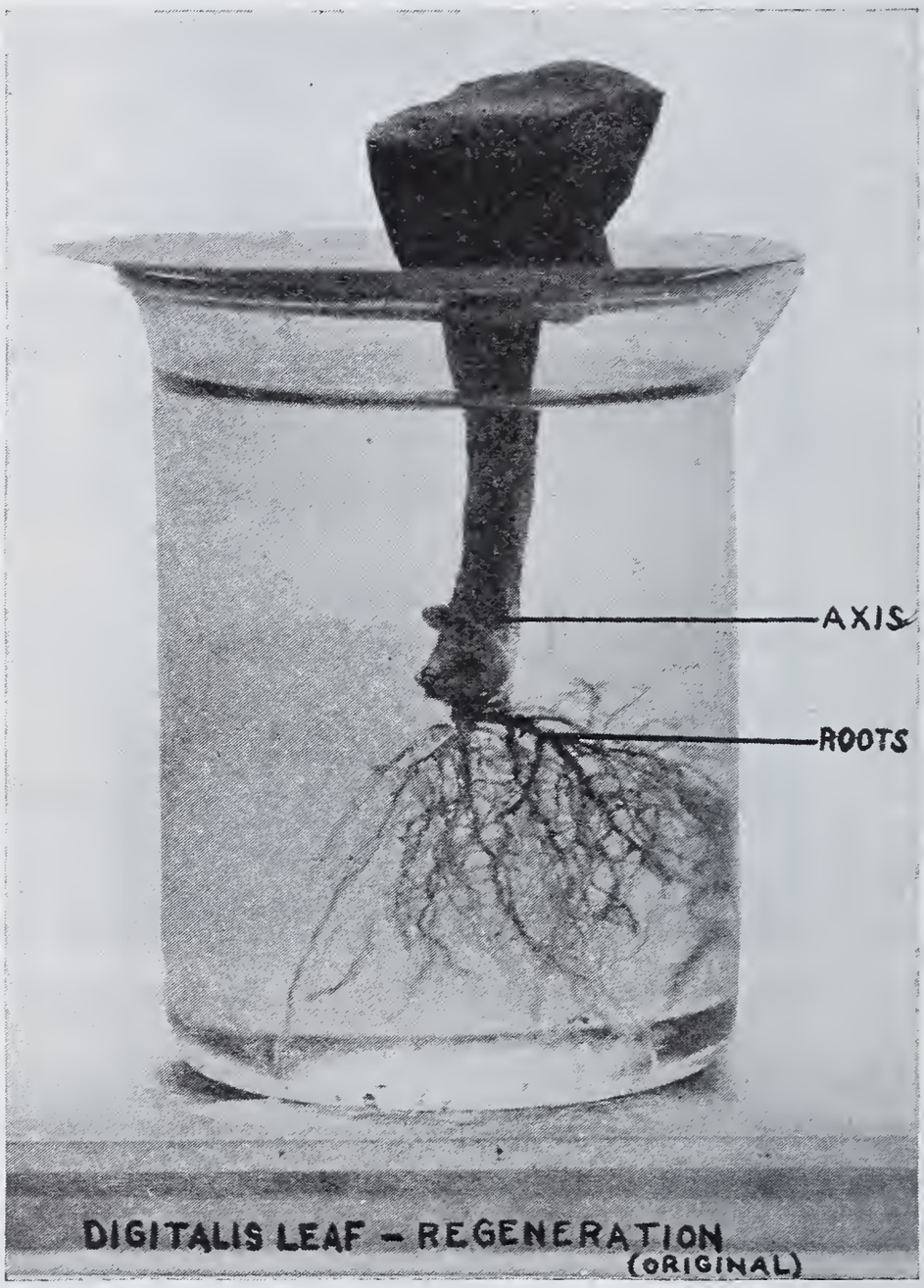


FIGURE 9.

New Growth on Base of Leaf, Completely Detached From Plant.

is a well-known faculty of human tissue. Transplanting of bones, of skin and even of kidneys and eyes (for animals) has been accomplished. Facial surgery has accomplished wonders in restoration.

Voronoff transplanted ape glands and human glands on human beings. He placed the right lobe of an ape's thyroid with its parathyroids in the little cell which should have been occupied by the missing left lobe of a boy, fourteen years old, whose general condition of health was very poor and whose intelligence was far below that of children of his own age. The results were very beneficial and lasting as far as an examination fourteen months after the operation could indicate. Another operation, transplanting the thyroid lobe from the mother, forty years old, to her suffering boy, resulted also in a physical and intellectual progress, though this was far more gradual than in the case of the graft of a young, three month old, ape's gland.

Rejuvenation.—The process of rejuvenation through vegetative reproduction and frequent transfer to new nutrients has been mentioned for bacteria. Many successful experiments of regeneration constitute rejuvenation. We have rejuvenation of tissue, if we remove parts of tissue, as, for instance, the leaves in lettuce, grass blades in lawns, parts of geranium, begonia or ageratum.

That transplanting rejuvenates tissues has already been mentioned. The exposure of plants, especially buds, to radiation of Roentgen rays, has a conspicuous stimulative effect on them.

The process of aging in plants is little understood. In some plants full maturity, expressed in flowering and fruiting, terminates the life cycle. If we delay this maturing and fruiting we may keep the tissue alive much longer. That through continued vegetative growth, the relative vein tissues formed become smaller, is pointed out by Benedict, who experimented with grapes, and examined tissue from plants, three, eight, fourteen, twenty-eight and sixty years old. (Fig. 10.)

Similar observations were made with leaf-vein tissue of willow, chestnut and other trees. The intensity of carbon dioxide assimilation and respiration, and the number of stomata are reduced with increasing age. Vegetative reproduction of fruit trees also finally yields trees which show signs of age, through slow growth, sensitivity to climate and soil—degeneration of the strain.

Here is where, likely, sexual production, a joining of the male and female sex cells, must take place to produce anew the "divine" embryonic cells for the sake of "lost virility."

In rejuvenation of animal tissue various methods have been used, *paralleling* nature's feat, triumphing over old age with sexual

reproduction. Steinach and Holzknecht, with the use of Roentgen rays, acting upon the generative glands (ovaries), advanced the state of maturity in immature guinea pigs and rejuvenated aged glands of women.

Voronoff writes in his book, entitled, "Life," concerning his experiments with goats: "I can affirm that some goats for two years and others for three have enjoyed good health which they did not possess during the years immediately preceding the graft, that some among them have procreated young, something they had been altogether incapable of doing for a long space of time, and that instead of pitiful beasts, timid and dejected, showing the marks of senile

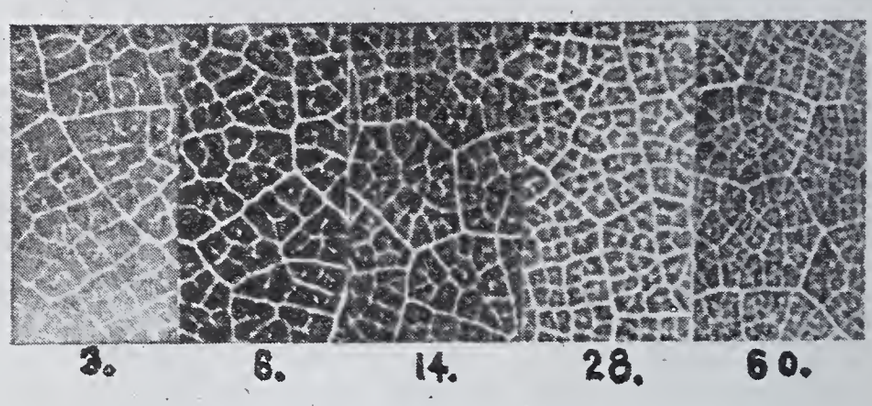


FIGURE 10.

Degeneration Through Continued Vegetative Reproduction. Grapevine (Vitis vulpina). Leafvein tissue of young plants becomes constantly smaller, as shown in the illustration of tissues from 3, 6, 14, 28 and 60 year old grapevines. (After Benedict.)

decrepitude, they have once more become superb animals, full of spirit, aggressive and belligerent. And since I have seen them in their wretchedness, and the only treatment given them has been the grafting on them of sex glands taken from young animals, I am convinced."

Harms experimented mainly with dogs, transplanting the sex-gland of a three-month-old male dog or on a sixteen- or seventeen-year-old dog that was almost dying from weakness. The transplantation had a greatly stimulating effect, which through two subsequent transplantations of gland tissue from the same animal was retained practically until rather sudden death 200 days later.

Steinach used a different method, discussed at length by Kammerer in his book on the prolongation of human efficiency. "As a result of experiments with rats from the same litter, the fact was established that the rejuvenated brother always lived seven to nine months longer than the brother that had not undergone a ligation of the spermatic duct. As the average rat hardly ever lives longer than thirty-one months, the postponement of the probable time of demise amounted to about one-fourth of the average length of a rat's life." Concerning the effect on man he states, "It is one of the foremost symptoms of rejuvenescence, brought about by vasoligature (cutting and tying of the sperm duct) that in cases where poor teamwork of the glands disturb the general health of the patient, this teamwork is

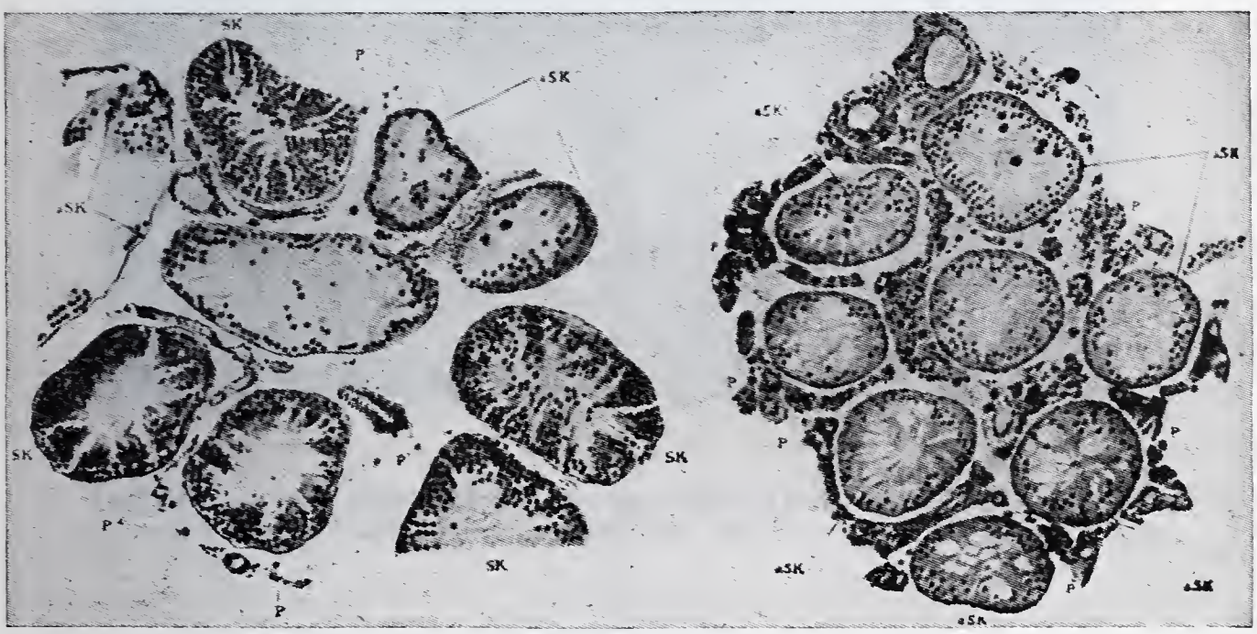


FIGURE 11.

Rejuvenation of Rats. Generative glands of Senile male rats (Microscopical section). Left picture: Senile condition. Right picture: Revivified condition after ligation of spermatic duct. aSK—Seminal canals in the process of perishing. Interstitial tissue (P) in right picture decidedly better developed on account of ligation and replacing empty spaces in senile glands. (Steinach.)

improved; a glandular equilibrium, so to speak, is brought about by the Steinach operation and with this a general improvement of the patient's condition." (Figs. 11 and 12.) Haire in his new book on rejuvenation in general agrees with Steinach.

Voronoff, equally enthusiastic as Kammerer in regard to rejuvenation, states: "The surgery of the future lies in the grafting of our organs, our tissues and our glands. The ideal toward which our efforts tend is to preserve life in the plentitude of its diverse and multiple manifestations, to force death to retract to its farthest limits."

Many workers, in contrast, have expressed their doubts concerning rejuvenation, and even reported failures as result of their experiments carried out with methods mentioned, or with extracts from generative glands.

The interesting chapter is not closed—the fight for youth is going on!

FIGURE 12.

Rejuvenation of Man. A. Fifty-six year old patient before the Steinach operation. B. Four months after the Steinach operation. (Ufa-Steinach-Film.)

VI.

Biological and Economic Significance.

In discussing growth and the conditions which affect it, favorably or unfavorably, we have come to realize the progress which has been made in the understanding of life and the process of development in particular. We know now that most complicated chemical and physical changes continually take place in living cells. If we modify but one phase the entire system is bound to be altered. Actual knowledge replaces more and more the fear of the unknown. The microscope has enabled us to solve the mystery of transmission of many diseases.

The closer co-operation—now in the forming—of the best minds, chemists, biologists, physiologists and all representatives of the other branches of natural science, tends to ultimately bring about the complete mastery of science of life. The protection of forests, water-

ways and of fertile agricultural land from industrial indifference or greed is under way. Many problems of disease and general welfare are already solved. The need for adequate nutrition is recognized. The proper functioning of the body glands is known to be essential.

Physical and mental development is coming under the control of man. Not only is he learning to maintain his health, to extend his span of life, but he is sensing his ability to engineer the growth of animals and plants according to his need and taste, to apply nature's laws—and to more fully utilize nature's products, nature's resources.

Man begins to appreciate his partnership with the Cosmos and to feel his unity with the universe.

FREE POPULAR SCIENTIFIC LECTURES

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The season of 1925-26 will see the continuation for the fifth successive year of these Popular Scientific Lectures by members of the Faculty of the Philadelphia College of Pharmacy and Science.

During the four preceding years these lectures were given in the College building at 145 North Tenth Street.

This year, through the generous co-operation of the Department of Instruction of the Y. M. C. A., the lectures will be delivered in Room 220 of the Central Branch Building at 1421 Arch Street, which has been set apart for this purpose.

The science-loving members of the community who have attended these lectures in increasing numbers each season will doubtless willingly transfer their faithful patronage to the new location, which is more easily accessible and especially suitable for such a purpose.

The new series will cover an entirely different list of subjects from those included in any of the previous courses.

As has been customary in the past, the lectures will be appropriately illustrated by lantern slides, specimens, etc.

The scientific information will be given as heretofore in a form easily comprehended by any person interested in science, but with no sacrifice of scientific accuracy or dependability.

The lectures, as will be seen by referring to the enclosed program, are in no sense interdependent. Each lecture is complete in

itself and you are cordially invited to attend any one or the entire series, as time, inclination or interest in the subjects, permits. No card of admission or formal invitation is required. You may come as often as you like and bring as many friends as you choose.

We shall feel repaid in proportion to the interest that is displayed by those who take the opportunity to attend.

A brief abstract of each lecture will be broadcast from Station WIP, Philadelphia, on the Saturday immediately following its presentation at the Y. M. C. A. The time to tune in is 8 P. M.

The Lectures Will Begin at 8.15 P. M. and End by 9.30 P. M.

First Lecture **Thursday Evening, October 8, 1925.**

THE FLIGHT OF A BALL THROUGH THE AIR.

By George Rosengarten, Ph. D.

Instructor in Physics, Philadelphia College of Pharmacy and Science.

This problem is an all-important one, entering as it does into the various sports in which we all engage. Baseball, Golf and Tennis in particular will be considered. From the moment that the ball leaves the pitcher it is acted upon by inanimate forces until it is struck by the bat, when a combination of physical and physiological forces react and send the ball in the opposite direction.

What is the cause of a curve ball? Where is the best place on the bat to hit the ball? Why is it necessary to have a standard ball? These questions and many others will be carefully considered from a scientific point of view. Experiments and charts will supplement the lecture so that all may understand the operation of the forces of nature which play so important a part in our national game of baseball.

Second Lecture **Thursday Evening, October 22, 1925.**

THE DIAMOND AND ITS COLORED BRETHREN.

By Freeman P. Stroup, Ph. M.

Professor of Chemistry, Philadelphia College of Pharmacy and Science.

It seems to be a far cry from milady's diamonds to the polish used on the kitchen range, or from the material used to clarify sugar

solutions to the grease in the crankcase of an automobile; but these and many other articles of more or less general use owe their value, wholly or in part, to some form of carbon. This lecture will deal with carbon in its varied forms, and an attempt will be made to cover, in non-technical language, the important utilizations of these. The lecture will be illustrated.

Third Lecture **Thursday Evening, November 5, 1925.**

ENVIRONMENT—THE BIG FACTOR IN HEALTH AND DISEASE.

By Louis Gershenfeld, B. Sc., Ph. M.
Professor of Bacteriology, Philadelphia College of Pharmacy and Science.

The old idea of heredity as the cause of many of the diseases afflicting mankind, is no longer tenable. However, this is still one of the many false and misleading views held by the laity. Environmental conditions are the big factors that produce an abnormal state of health. The injury they cause cannot be accurately measured. It is our environment which affects our standards in regard to what we think is beautiful and healthy. If we wish to enjoy living, it is our duty to be active in the everlasting campaign against disease. With a better understanding and appreciation of our exact knowledge, preventive measures can be carried out along more intelligent and useful lines.

Fourth Lecture **Thursday Evening, November 19, 1925.**

MORE ABOUT COLOR AND COLORS.

By J. W. Sturmer, Ph. M., Pharm. D.
Dean of Science, Philadelphia College of Pharmacy and Science.

Many things in nature which exhibit color, contain no coloring matter. Such color effects, usually spoken of as "structural colors," are shown by certain rocks and precious stones, by bird feathers, by

insect wings, and by many familiar objects. The lecture will be illustrated with material from many sources,—some from the Philadelphia "Zoo."

Fifth Lecture **Thursday Evening, December 3, 1925.**

THE ROMANCE OF MEDICINES.

By Charles H. LaWall, Ph. M., Sc. D.

Chemist to Food Bureau, Pennsylvania Department of Agriculture; Dean of Pharmacy, Philadelphia College of Pharmacy and Science.

Many of the popular remedies which are more or less widely used and known to the laity have had romantic or dramatic origins, and interesting histories. One popular remedy of a century ago, still occasionally used, was called Vinegar of the Four Thieves, because a band of robbers during one of the plague epidemics in France, used it as a prophylactic against disease.

In like manner such common remedies as Seidlitz Powders, Blaud's Pills, Cold Cream, Dover's Powder, Fowler's Solution, Friar's Balsam, Laudanum, Paregoric and many others have a tinge of romance or of tragedy in their history. The lecture will be illustrated with lantern slides and specimens.

Sixth Lecture **Thursday Evening, December 17, 1925.**

WHAT SHALL I DRINK?

By Horatio C. Wood, M. D.

Professor of Materia Medica, Philadelphia College of Pharmacy and Science.

From earliest historical times mankind has supplemented his food with various beverages, such as beer, wine, coffee, tea, etc. This lecture will cover the history of the use of these and some of the less known drinks, and also give an account of their effects on the body and the results of their habitual use.

Seventh Lecture Thursday Evening, January 7, 1926.

DELECTABLE CONFECTIONS.

By E. Fullerton Cook, Ph. M.

Professor of Operative Pharmacy and Director of the Pharmaceutical Laboratory, Philadelphia College of Pharmacy and Science.

The love of "sweets" is as old as the race, yes, apparently as old as animal life, for the ant and the elephant vie with man in appreciation and delight of sweet things to eat. Our generation has lavishly provided the "good things" of earth, but probably in no field so abundantly as in that of confections.

Not only are candies of today unrivalled in variety, attractiveness and cheapness, but the sanitary condition of the factory and the purity and digestibility of the product made in the United States exceeds anything heretofore considered practicable.

The story is almost as fascinating as the "chocolates" themselves and the alluring odors of the factory can almost be sensed as one sees, even by picture, their production on a gigantic scale.

Eighth Lecture Thursday Evening, January 21, 1926.

SOME THINGS NOT OFTEN SAID ABOUT MILK.

By David Wilbur Horn, Ph. D.

Professor of Physics and Physical Chemistry, Philadelphia College of Pharmacy and Science; Professor of Inorganic Chemistry, Wagner Free Institute of Science.

What is usually said about milk has been said over and over so often that it is timely and profitable to depart from this custom. Milk is not as yet well understood; a start has been made in its physiology and pathology, the physical chemistry of milk is in its infancy, the bacteriology of milk is advanced as far perhaps as early adolescence. It is one of the profoundly significant factors in mammalian life, and it lends itself more readily than the others to sophistication and misrepresentation. To be ignorant and indifferent concerning milk is a crime against self, offspring and fellow,—a crime punishable in many instances by torture, suffering and death.

Ninth Lecture Thursday Evening, February 4, 1926.

THE SIGN OF THE SKULL AND CROSS-BONES.

By Ivor Griffith, Ph. M., P. D.
Physiological Chemist, Stetson Hospital; Assistant Professor of Pharmacy, Philadelphia College of Pharmacy and Science.

What is a Poison? Some legal and scientific definitions. The Poisons and Poisoned of History. Poisoning was a fine art when Rome was Roman. According to the Eddyites it is still so today, for the art and practice of medicine deal largely in poisoned potions to alleviate human ills.

Cultivating a tolerance for poisons, Poison myths and fallacies. Poisons which neutralize one another—forming by their union a harmless compound. Poisons, on the other hand, may be produced by the union of two inoffensive substances. Thus hydrogen the harmless, nitrogen the inert and carbon may be linked together to make "Poison more deadly than a mad dog's tooth." Ricin, the deadliest of all poisons, is a constituent of the same plant that produces castor oil—a "poison" only to little children.

Tenth Lecture Thursday Evening, February 18, 1926.

THE SALT OF THE EARTH.

By Edward J. Hughes, P. D.
Assistant Professor of Chemistry, Philadelphia College of Pharmacy and Science.

Where is there a more useful and a more necessary substance than common salt? Because of their abundance in nature we are so apt to look upon such essentials as air, soil, water and salt as the common things of the earth. Yet the chemist has recently revealed that we are just beginning to learn something about the significance of salt. Man has been adding salt to his food for ages. Later on he began using it to preserve fish and meat. But it was when the little salt molecule was decomposed into a silvery white metal called sodium, and a greenish-yellow gas called chlorine, that men of science recognized salt as one of the treasures of the earth.

It has been shown that a close relationship exists between the history of salt and the history of man, and that the color of man is actually dependent upon salt.

Reference will be made in the lecture to the many industrial applications of salt, pointing out how it has been utilized in the frightfulness of war as well as in the commercial enterprises for the benefit of mankind.

The lecture will be illustrated with experiments, lantern slides, and specimens.

Eleventh Lecture Thursday Evening, March 4, 1926.

IMITATION OF LIFE.

By Arno Viehoever, Ph. D.

Professor of Biology and Pharmacognosy and Director of the Botanical Gardens, Philadelphia College of Pharmacy and Science.

A brief discussion of the meaning and essentials of life is to be followed by an account of the fruitless attempts through the ages to create life (spontaneous generation) and of the success in copying important functions of living organisms. The aim is to demonstrate the progress made in imitating life, the present status and limitations and to conclude with a general outlook of the possibilities ahead.

The lecture will be illustrated with lantern slides and experiments.

Twelfth Lecture Thursday Evening, March 18, 1926.

ABNORMAL PLANT GROWTHS (GALLS).

By Marin S. Dunn, A. M.

Assistant Professor of Botany, Philadelphia College of Pharmacy and Science.

Galls are abnormal growth produced in plants by plant and animal parasites. They are of special interest to us because many are harmful to our ornamental and economic plants, because some are of benefit to us in tanning, dyeing, ink manufacture, as local astringents, etc., and because connected with them is the fascinating

problem of abnormal plant growth. Wide in their distribution throughout the plant kingdom, curious in their form, strange in their history, plant galls are of never-failing interest. The lecturer will cover the following topics: (1) organisms causing gall formation; (2) structure of typical gall; (3) possible explanations of the origin of galls; (4) development of the gall; (5) benefits of the gall to the parasite; (6) injurious galls; (7) beneficial galls.

The lecture will be fully illustrated with specimens and lantern slides.

Thirteenth Lecture **Thursday Evening, April 1, 1926.**

THE WONDERS OF THE MICROSCOPE.

By Henry Leffmann, A. M., M. D.
Lecturer on Research, Philadelphia College of Pharmacy and Science;
Hon. Professor of Chemistry, Wagner Free Institute of
Science, Etc.

The microscope is probably the most exact instrument employed in research. A vast amount of theoretical study and high mechanical skill has been expended on its development and construction, and its services embrace every department of science. From the enormous material available for illustration of the useful and impressive views revealed by the instrument, the lecture will comprise a selection of lantern slides adapted to show the variety of its applications. Incidental mention will be made of the so-called ultra-microscope adapted for examination of objects too small for detection by ordinary instruments.

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